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EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

No. 3

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CONTENTS

A New Stage in the Development of Health Inspection of Sources of Electromagnetic Radiation in Moscow.. 1

On Conditions Necessary for Investigating the Biological Effects of Microwaves.. 4

Cellular and Molecular Effects and Mechanism of Action of Microwave Electromagnetic Fields on Biological Systems.................................. 8

Psychoses in Radiowave Disease.. 21

Mechanism for the Effect of Electromagnetic Fields on Cardiac Contractile Activity.. 27

Effect of UHF Electrical Field on the Blood Coagulation System in Animals.. 32

Significance of Blood Lipid and Electrolyte Disturbances in the Development of Some Reactions to Microwaves... 37

Calcium and Magnesium Concentrations in the Tissues of Rats Exposed to an Electromagnetic Field of Industrial Frequency........................... 40

Special Features of Carbohydrate-Energy and Nitrogen Metabolism in the Rat Brain Under the Influence of Magnetic Fields of Commercial Frequency. 42

Effects of HF and UHF Radiation on the Organism and the Principles of Standardization 50

Causes of Off-Duty Accidents Among Agricultural Workers 50

Effect of Heterogeneous Magnetic Field on Human Erythrocytes 51

Free-Radical Activity of Mitochondria Following Exposure to Electrostatic Field 51

Dynamics of Proteolytic Changes in Rat Liver Following Exposure to Electrostatic Field 52

Treatment of Viral Hepatitis Patients With Localized Magnetic Field 53

Application of Microwave Hyperthermia in the Treatment of Malignant Tumors. 53

Using a Permanent Magnetic Field in Treatment of Injuries to the Locomotor System in Experiment and Under Clinical Conditions 54

Variable Magnetic Field Used in the Treatment of Herpetic Disease of the Eyes 55

Mechanism of Antiinflammation Effect of Microwaves 55

The Magnetic Susceptibility of Microorganisms 56

The Effect of an Experimental Magnetic Storm on Production of Phage λ 56

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A NEW STAGE IN THE DEVELOPMENT OF HEALTH INSPECTION OF SOURCES OF ELECTROMAGNETIC RADIATION IN MOSCOW

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 10, 1979 pp 49-51

[Article by A.I. Appenyanskiy, Z.V. Gordon, and A.V. Tsessarskiy, Moscow Sanitary Epidemiological Station]

[Text] The branch of health inspection concerned with sources of electromagnetic fields and radiation (EMF) is now becoming an increasingly important aspect of hygiene. By EMF we mean constant electric and magnetic fields, intermittent low-frequency EMF, and radiowaves (radio-frequency EMF). Exposure to either natural or artificial EMF is known to produce many biological effects. Artificial EMF are important under both industrial and external environmental conditions (Yu.A. Osipov, Z.V. Gordon, M.I. Yakovleva, A.P. Dubrov, Yu.D. Dumanskiy et al., Yu.A. Kholodov, and V.G. Lazarovich).

Monitoring sources of EMF in industry and the environment is important because electromagnetic energy is widely used in the economy to replace fuels (in heat treatment), cutting tools (laser beam), etc. Wireless communications and ranging (radiowaves, laser radiation) are expanding. We are on the threshold of using magnetohydrodynamic generators of electrical energy. EMF as an aid in technology are attracting the attention of industrial workers because they make it possible to accelerate industrial processes substantially.

The industrial use of EMF is confronting health officials with the need to deal with such matters as the effect of emissions of radio and television stations on the population, static electricity in daily life, transport, and industry, and constant and infralow-frequency magnetic fields (development of mineral resources, some forms of production, transportation, everyday life). Industrial areas partly or completely screened from external (natural) EMF constitute an urgent problem.

Thus, the first laboratory for monitoring sources of EMF in industry was established in the industrial health system in Moscow in 1968. It also became a base for acquiring experience in organizing specialized industrial health inspection in connection with EMF.

Since our laboratory has been in existence (1968 to 1979) it has been registering and regularly inspecting Moscow industrial plants in which personnel are exposed to EMF in workplaces. It has made about 300,000 measurements of EMF levels and registered over 2000 EMF generators of different frequencies. Analysis of the results of laboratory monitoring showed that maximum permissible levels of EMF were exceeded in 37 percent of the industrial areas with sources in the long-wave, medium-wave, short-wave, and ultrashort-wave bands when they were first inspected. They were also exceeded in 29.04 percent of cases in stationary workplaces of operators of industrial EMF generators. In the course of organizing specialized industrial health inspection, we worked out the structure, functions, methods of work, forms of operational and statistical documentation, techniques of measuring EMF levels under industrial conditions, recommendations for preventive health inspection, regulations for laboratories and laboratory specialists, and criteria for evaluating the work done by sanitary-epidemiological stations in monitoring EMF.

Analysis of the work done by the EMF laboratory of the municipal sanitary-epidemiological station showed that a new stage has been reached in the development of this type of health inspection. The first task to be performed in this stage is to extend inspection to all regions of the spectrum of nonionizing EMF because standards have by now been set and approved and there are regulations for handling sources of EMF in most frequency bands (constant fields, industrial-frequency electric field, low-frequency pulse electromagnetic field). Hence the city's health service is confronted with the need to intensify the objective inspection of working conditions of the individuals who handle sources of EMF in all bands.

The second task of the city's health service is to check EMF levels in the environment.

The third task is to improve the inspection of working conditions of individuals handling sources of EMF in industry and to thoroughly inspect the industrial areas where the operators are exposed to a combination of hazardous factors.

In making a comprehensive evaluation of working conditions, we emphasize the connection between human physiological functions and working conditions. We also study the health of workers as indicated by morbidity data and the results of periodic medical checkups.

Health inspection of sources of EMF cannot be improved without improving the system of prophylactic (preventive and periodic) medical checkups of individuals exposed to this industrial factor. Hence we believe it is necessary that physicians doing the checkups be given special training for this purpose.

The need for careful evaluation of the health of those working with sources of EMF, even though there is no direct evidence that they are harmful, arises from the fact that they may have nonspecific maladaptive effects on the workers as manifested by lowered resistance to other injurious environmental factors and to infection. They are also associated with a higher incidence of ischemic heart disease and other ailments.

The fourth main approach to improving the inspection of working conditions involving exposure to EMF is to increase it in the stage of designing and pilot production of equipment that emits EMF. There should be a rule that no single type of newly designed technological equipment with sources of EMF can be introduced into actual production until it is first evaluated from the health standpoint.

Health inspection can be further improved by subjecting EMF levels of health laboratories of industrial plants to laboratory monitoring.

Implementation of the above-mentioned tasks requires the participation of specialists from the rayon branch of the health service. These specialists are now concerned with the active discovery of industrial areas with sources of EMF, daily monitoring of working conditions, making comprehensive evaluations of working conditions in areas involving exposure to a combination of hazardous factors, verification of health appraisals by experts of sources of EMF in the design, pilot and series production stages, and prompt monitoring of newly introduced protective and sanitary measures.

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ON CONDITIONS NECESSARY FOR INVESTIGATING THE BIOLOGICAL EFFECTS OF MICROWAVES

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, 1979 pp 70-72

[Article by S.L. Arber, Moscow]

[Text] The question of the nonthermal mechanism through which microwaves act on living systems is now basic throughout the entire problem of biological effects from nonionizing radiation. In a review article[1] dealing with cellular, subcellular and molecular effects from the action of microwaves, the conditions essential for observing these effects have been presented. These are the duration of the process of irradiation (of the order of tens of minutes and more) and the maintaining of temperature constancy in the system during the irradiation process. These will be discussed in more detail.

The Role of the Temperature of the System During Irradiation

In a dielectric located within an SHF field (a biological system is also within this frequency range) part of the energy of the electromagnetic field, as is known, is converted into heat and the temperature of the material rises. SHF heating based on dielectric loss is widely used in industry, chemical technology and medicine. Recently, the thermal effect of the SHF action was assumed to be the basic mechanism for biological effects from microwaves. Given the thermal capacities from radiation, it is not always possible in fact to detect the "specific" mechanism involved in microwave effects.*

At the same time, work has been done (see, for example 1, 2; as extremely typical we note 3), from which it follows very clearly that the nature of the microwave effect is nonthermal. Thus, during irradiation of an isolated turtle heart[3] at 100 mW (absorption 3.3 mW, heating less than 0.5°C) bradycardia (slowing of heart rate) is observed, while at 300mW with normal heating, tachycardia (increased heart rate) is observed. Hence, increasing the temperature of the irradiated object distorts its reaction. In most work in which a constant temperature was maintained during irradiation, the parameter being tested differed from the control, while in work without temperature control, it was the same.[1] In the language of information theory, this kind of situation can be regarded as an increase in thermal noise in the system (the magnitude of the noise is proportional to the temperature of the system) during irradiation. This in turn interferes with conversion of the input signal (the SHF oscillation) and the output signal (the response of the system). At low powers for the effects, an increase in the level of temperature noise is insignificant and the data signal is realized in the system response. Note that in experimental physiotherapy it has also been observed that the greater the heat conversion in the process of irradiation, the less the specific effect of the microwaves.[4] Evidently, the data accumulators should be structures that are only weakly linked with dissipative processes in the system, for example, the internal fields of a macromolecule through its greater hardness and considerably fewer numbers of collisions. It should not be thought that the informational character of the microwave action in this kind of examination means that it is not of an energetic nature. Energy is needed, but it is very low compared with the energy of the processes that trigger the microwaves. At first glance it may seem that if the energy quantum of the SHF field is considerably less than the energies of a molecular system, the mechanism by which the microwaves act upon biological systems can have no other nature other than heat. This conclusion, however, is based on an energy approach that is correct if the system is in a state of equilibrium. Living systems, however, are substantially nonbalanced and nonlinear.[5] These properties insure the presence in them of a multiplicity of steady state and nonsteady state conditions between which there are transitions even at low excitation levels. On this basis, in nonlinear systems control is possible with the aid of relative weak influences. All organizational levels in biological systems are liable to regulation and control, including the molecular level. In the case of protein macromolecules the conformational arrangement corresponds to that of the discrete levels of free energy, the difference between which is great compared with the quantum of the SHF field. At the same time, given insignificant localized disturbances, the configuration of the molecule can be altered.[6] Herein lies the feature of biological macromolecules, since they are dynamic structures rather than statis systems. The transition time between conformation states is therefore relatively great.

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*An indication of the specific nature of the effect of microwaves allegedly stemming from experiments to investigate the effect of microwave thermal capacities on the vitality of Escherichia coli, bacteria reproduction and so forth[2], in which the effect was observed more rapidly than in a control (convection or infrared heating) is not correct, since in the SHF field there was more even heating throughout the entire volume (therefore requiring less time), while in the control it took place from the surface, and hence was less efficient. In fact, this advantage of SHF heating is also used in industry.

In oligomer enzymes [7,8] the interaction of reagents and ligands with certain trigger sites on the macromolecule can set in motion a definite mobility mechanism that effects transition of the enzyme into a new conformational state. Thus, biological systems are trigger systems capable of transferring to other operating modes when acted upon by weak signals. It is here that the informational nature of biological systems are manifest. And in this sense, an increase in the temperature of a system disrupts the processes of data input and processing associated with the protein structures.

The Need for Prolonged Irradiation

In a considerable portion of the work in which a microwave effect has been recorded, the period of the action is of the order of tens of minutes and more.[1] Typically, irradiation (λ=10.4 cm, W=10mW/cm^2) of a frog for 0.1 of an hour over 20, 40, 60 and 100 days has not led to any kind of changes in the muscle cells[9], but as the result of a 2-hour exposure (with the same parameters) definite changes in the electro-physiological characteristics of muscle cells were noted by the same authors in a nerve-and-muscle preparation.[10]

It has been suggested elsewhere[1] that the dependence between the system response and the duration of irradiation is associated with the realization of processes requiring large time characteristics. One such process could be conformation transition in a macromolecule, which is characterized in minutes and longer. In fact, it has been shown that the kinetics involved in conformational rearrangements induced by ligands can be quite slow. For example, the half-conversion time for ATP-induced transitions in D-glyceraldehyde-3-phosphate dehydrogenase as recorded from polarization changes in a fluorescent specific tracer is 40 minutes, with 19 minutes of activity.[11]

In order to trigger conformational rearrangement of a molecule with microwave radiation it is essential that the radiation is absorbed in the trigger sites of the molecule. Evidently it is not mandatory that the SHF-trigger site should coincide with that of the ligands or that each macromolecule should contain such a site. It is suggested that the SHF trigger is located either in the cavities of the macromolecule or in its hydrophobic section, and that it includes one or several polarized groups. A polarized group possesses a set of rotational states and is in one of the minima of a multiwell potential, which determines its spatial orientation relative to the other groups making up the trigger site. Excitation of this group by an SHF field as the result of an energy buildup (because of the absence of dissipative processes) transforms it into another spatial orientation, as a result of which the mechanism that effects the tranformation of the macromolecule into a new state with an altered tertiary or quaternary structure, is activated.

On the basis of the above it can be concluded that the response time for a system is composed of t_1, the time for group energy buildup necessary for alteration of its spatial orientation, and t_2, the time taken for conformational rearrangement of the macromolecule. In practice, irradiation time equals system response time because the response is always seen immediately after the action. If, however, there are no changes in the recorded parameter, then irradiation time should be increased or it should be considered that the microwaves are not affecting this parameter of the system. It follows, however, from the examination conducted above that the minimum time for the effect can correspond only to t_1, while the system reaction is seen after a specific lag--a period equal to t_2. We do not know of any experimental work from which there is any indication that the lag period does exist (the time between the end of irradiation and the manifestation of system response), but this is probably associated with the method indicated above for studying system reaction to the microwave action. At the same time, there is proof on the duration of SHF-irradiation (1 hour) for alteration in molecular conformation.[12]

Thus, it can be suggested that rearrangement of the quaternary structure of proteins leading to alteration of their intramolecular and intermolecular contacts is primary in the observed changes in the structure and functional properties of membrane systems in an SHF field.[1]

In conclusion we note that the first person to formulate the hypothesis on the role of trigger processes in the sensitivity of biological systems to electromagnetic fields was Yeydi (see for example 13 in the bibliography). But the existence of triggers in living systems has as its basis the unbalanced and nonlinear properties of such systems. It is on these qualities that the approach to an understanding of the nature of the interaction between microwaves and living systems should be based.

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CELLULAR AND MOLECULAR EFFECTS AND MECHANISM OF ACTION OF MICROWAVE ELECTROMAGNETIC FIELDS ON BIOLOGICAL SYSTEMS

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 3, 1978 pp 59-65

[Article by S.L. Arber, Moscow]

[Text] The interaction of microwave (MW) electromagnetic fields (EMF) with living organisms representing a great variety of species from unicellular ones to man has been under systematic study for more than 3 decades. Much experimental material has been collected during this time on the varied effects of MW on humans and animals [1-3]. This information has helped solve many hygienic and clinical problems caused by this factor, but the biophysical mechanisms underlying the biological action of MW, a major interest not only of theoretical biology, are still obscure.

Study of the role of EMF in the evolution of living systems and the influence of solar activity on the earth's biosphere and the protection of the screws of spacecraft against their own and relict radiation as well as the further use of MW in medicine and agriculture are linked to progress in research on the mechanisms of the biological action of MW.

It goes without saying that the problem cannot be solved without research using as models isolated cellular and subcellular structures and solutions of different biomacromolecules. This research is the subject of the present article.

Effects and Mechanisms at the Cellular Level

The variety of cellular effects produced by EMF, according to [1], can be divided into two groups possessing the following characteristics: (i) definite orientation, arrangement in chains or directed movement of unicellular organisms (electromechanical effects) and (ii) change in physiological functions.

It is now clear that the first group of effects can be explained from the standpoint of electrodynamics and a knowledge of such quantities as field intensity, dielectric permeability of particles and medium, and geometry of particles is quite sufficient for forecasting their behavior in EMF [4-10]. Experiments involving the action of EMF at frequencies of 20 and 50 MHz on killed unicellular organisms [11] again demonstrated that the phenomenon of transverse orientation of elongated particles in EMF is not caused by the specific action of microwaves because the organisms used were not live.

it is also clear that these effects obviously have no biological significance. This was shown by one of the best known and most studied phenomena of this group--the pearl chain effect. The main characteristics of the phenomenon are as follows: (i) alignment in chains takes place only when the field intensity is greater than the threshold value; (ii) the threshold value of the field is independent of the frequency and inversely proportional to the radius of the particle; (iii) the time constant of pearl chain formation is proportional to the cube of the radius of the particle and inversely proportional to the square of the field intensity.

The threshold of chain formation for particles with a radius of 10μ is equivalent to a field intensity of the order of 2.5 V/cm. With a power flux density of $\sim$10 mW/cm^2, the field intensity in tissues is less than 1 V/cm. Therefore, chain formation at these densities is possible only in the case of particles larger than 10 μ. Since the time constant of chain formation for particles smaller than 10 μ is much larger than the time required for the medium to warm up under the conditions prevailing in ordinary radar installations and since there are no freely spinning particles greater than 10 μ in tissues, it is concluded [10] that this effect has no biological significance.

The mechanisms of the second group are linked to the action of EMF on subcellular structures and macromolecules. Cells were shown [13-15] to absorb MW of certain frequencies (millimeter range) corresponding to regions of absorption of the cellular components. The absorbed energy alters the metabolic and biosynthetic processes and retards cell growth. Mention should be made, however, of [16] in which the effects described in [13, 14] were not manifested at the same frequencies. In the same range of frequencies, irradiation of RNA- and DNA-containing viruses led to a decrease in their infectiousness [17] while irradiation of Drosophila imagoes before mating affected their fecundity and viability [18]. Suppression of the growth of bacterial cultures and change in phagocytic activity and in protein biosynthesis were noted in references [1, 19, 20] (centimeter band). Ultrastructural changes are mentioned in [21, 22].

It follows from the foregoing that the first group of effects probably have no biological significance. The mechanisms of the second group must be sought at the molecular level.

Effects and Mechanisms at the Subcellular Level

In the 1969 Schwan [23] demonstrated theoretically that any voltage arising on the cell membrane as a result of rectification of an ultrahigh-frequency field with a power flux density of $\sim$mW/cm^2 will be less than resting potential by several orders and, consequently, it cannot affect the condition of a nerve cell. On the other hand, a few studies with mollusk and medicinal leech giant neurons as models [24] [27] revealed that MW change the membrane potential and background activity of nerve cells.

Another small group of recently completed studies [28-35] are concerned with the influence of MW (frequency 27 3000 MHz) on erythrocyte permeability. Except [35], they showed that the action of a field in the indicated band increases the concentration of intracellular sodium while decreasing the concentration of intracellular potassium and that it also causes hemoglobin to escape from the cells. Lysosomal enzymes are liberated in granulocytes [33,34]. The authors of these reports differ in their explanation of the change in ion transport across the membrane: from action of the field on hydration water in the membrane [29] to changes in energy metabolism resulting from conformational changes in the macromolecular complexes of the cell [32], passive permeability, and the K-Na pump [28, 31, 33].

Thus, what the two groups of studies have in common is an increase in ion permeability of the membrane after exposure to MW, which is obviously a manifestation of the nonspecific cell reaction to MW. The explanation of this effect will have to be sought at the molecular level.

Membrane permeability to a particular ion is actually believed to be a function of its mobility in the membrane and of the coefficient of distribution of this ion between the solution and the membrane [36]. The coefficient of distribution is determined, in turn, by the electrostatic interaction of the ion with ligand groups on the membrane and by the steric correspondence between the ion and the pore (spatial position of ligand groups, etc.). If we assume that ion mobility in a membrane is independent of the MW field (electric field intensity on the membrane of about 10^7 V/m while the intensity of the electric constituent of the MW field is about 10^4V/m), we shall have to examine the molecular mechanisms at the membrane-solution boundary. This is also indicated by the changes in electrophoretic mobility of cells and colloids after irradiation [37-39].

The effect of MW on substrate oxidation, electron transport, oxidative phosphorylation, and calcium transport in isolated mitochondria were also studied [40,41], but no changes were found in the course of these processes.

Effects and Mechanisms at the Molecular Level

Leaving aside dielectric saturation it requires very high electric field intensities, a minimum of several kilovolts per centimeter [42, 43], and therefore has little bearing on the problem, let us examine several studies on the effect of an ultrahigh-frequency field on the activity of a variety of enzymes [44-53]. Vogelhut [44], for example, observed changes in the rate of the reaction afyer exposing a solution of lysozyme and its substrate to an UHF field at a frequency of 10,000 MHz, but other investigators found no changes in lysozyme or trypsin activity when they used a frequency of 2450 MHz [45]. Irradiating cholinesterase and aldolase at 3000 MHz [46], dehydrogenase at 2800 MHz [47], malate dehydrogenase, alkaline phosphatase, and other enzymes at frequencies of 10-12, 700, and 2000-2600 MHz [48] produced no changes in their activity. An investigation of the catalase-hydrogen peroxide system in an UHF field likewise had no affect on the rate of the reaction [49], but changes did occur in a low-frequency field (27 MHz) [50]. A significant decrease in ATPase activity of actomyosin and myosin followed exposure to frequencies of 350 MHz [51] and 2400 MHz [52], respectively. Trypsin activity at the latter frequency did not change [52], but peroxidase activity (2450 MHz) did [53]. Investigators who observed changes in enzymatic activity assumed that structural reconstruction of water [51] or rupture of hydrogen, hydrophobic, or covalent bonds [52] was the underlying mechanism. It is interesting to note that in all the experiments referred to, enzymatic activity mostly remained unchanged or decreased (the systems in most cases were thermostatically controlled).

Accordingly, Alper [54] using nonequilibrium thermodynamics showed that such slowing of chemical reactions may be due to EMF disturbing the spatial orientation of polar groups in the active center of the enzymes (the completion of an enzymatic act requires the "freezing" of the rotational degrees of freedom of the reacting groups--EMF interfere with this). It is evident from [54] that the kinetics of an enzymatic reaction likewise does not change in an EMF if the active centers of the molecules contain no catalytic polar groups.

Closely related to this series of studies are those done on hemoglobin [55-57] which though not an enzyme can, of course, serve as a model thereof. The effect observed in [55-57] consists in a strengthening of the bond between heme and a protein (weakening of the bond between oxygen and the iron atom) upon the exposure of aqueous solutions of hemoglobin to millimeter MW, which can be regarded as a slowing of the rate of conversion of hemoglobin from the hydroxy- to the meta form. The hypothetical mechanism is linked to the rotational wobble of distal histidine (polar amino acid radical) in the active center of the macromolecule. In [58], the strengthening of the bond between heme and a protein was confirmed by gamma resonance spectroscopy.

The primary mechanism underlying the above-described effects is still somewhat obscure from the energy standpoint because the energy of thermal motion at room temperature (0.026 eV) exceeds the energy of a quantum of a MW field (10^{-4}eV at 3 GHz) by approximately two orders (not to mention the comparatively low activation energies for the rotation of protein polar molecules, 0.04 to 0.4 eV, rupture of the hydrogen bond, 0.08 to 0.2 eV, and hydrophobic interactions, 0,008 to 0.06 eV). To be sure, the activiation energy required for polar groups to rotate in proteins may be lower due to a decrease in dipole-dipole interaction(surrounding a polar group in a nonpolar manner), increase in mobility because of a decrease in the intramolecular interaction of a nondipole type, or increase in the flexibility of the molecules [59]. Moreover, starting with frequencies of 10^{10} to 10^{11} Hz the resonance type of absorption in polymers is possible. Although Schwan [60] believes the probability of resonance is low due to the high viscosity of water, this apparently does not apply to the hydrophobic regions of the macromolecule which contains within itself polar groups.

It should also be pointed out that we may be dealing here with an example of how the reactivity of molecules is significantly affected by weak intramolecular and intermolecular interactions whose energy is low compared to the energy of a bond or even to kT [61].

Physicists are familiar with a host of different quantum resonances whose frequencies are in the MW band. However, to observe them we need, in addition to a MW field, steady electric and magnetic fields which split the degenerated levels of the system in such a way that the frequency of the exchanges between them corresponds to MW. Such fields (electric) exist in a cell only on the membrane. In this connection we must mention [62] which discusses the mechanism of nerve excitation by a low-intensity EMF based on the assumption that layers of dipoles forming a two-level system are found on both surfaces of the axon membrane. The frequency of exchanges of the system correspond to the MW range. However, this quantum model of microwave excitation of nerves is limited in the sense that the action of the field may result only in excitation of the nerve (an inhibitory effect requires inversion population of the levels). Incidentally, MW radiation can be observed from such a system, but no information on this has as yet been published (only infrared radiation has been reported [63].

One of the most natural ideas that may underlie the mechanism of interaction between a low-intensity EMF and a biosystem is obviously the cooperativeness of the processes that take place on membrane surfaces [64, 65]. A disturbance at any one point may trigger conformational changes in the membrane molecules over a considerable distance, thereby altering cell functions. It must not be thought, however, that cooperativeness means an instantaneous response by the system to an external action, as might appear from the sharpness of the experimental curves of the phase changes. The kinetics of the process may be fairly slow [66] (concerning another hypothetical collective property of assemblies of biomacromolecules, coherent electric dipole oscillations whose frequencies are 10^{11} Hz, see [67]).

It was also hypothesized [68] that the high sensitivity of biological objects to EMF is due solely to the presence of superconductivity in biosystems. The hypothesis is based on theoretical predictions of high-temperature superconductivity in stratified and threadlike sturctures [69, 70] (a recent survey of high-temperature superconductivity [71-73] indirectly indicate that biomacromolecules may possess superconductivity at room temperature).

Antonowicz [74] using an Al-carbon--Al"sandwich" at room temperature recorded volt-ampere characteristics in a MW field similar to those found in Josephson contacts at low temperatures. The extremely high sensitivy of these contacts to MW radiation (of the order of 10^{-13} W/cm^2) explains the need for such an assumption.

Several ways are now available for raising the transition temperature. They involve creating special threadlike and stratified structures and converting the system to a steady state by means of external fields [71]. The latter case is considered only for substances with equilibrium superconductivity. However, the action of an UHF field may create a superconductive state in biomolecular structures like Little's hypothetical molecule [70] by exciting the side groups to oscillate and thus stimulating the interaction of electrons moving in the main chain. In this case absorption of the field will be determined by the resonance processes in these groups and the created superconductivity will interfere with the functioning of the molecular assemblies.

The question of high sensitivity of biosystems to EMF can also be examined from the standpoint of the theory of synchronization of oscillations [75] whereby two self-oscillating systems, however weak the link between them may be, invariably become synchronized if the difference between their partial frequencies is fairly small. Thus, even low-intensity Mw radiation will be perceived by a system when its frequency is close to the partial frequency of the object. Only the time required to establish synchronization is important here. Viner [75] advanced the hypothesis that the specificity of a macromolecule is assured by the frequency structure of its molecular radiation to a substantial part of which may be in the infrared band or lower. To check the hypothesis, it was proposed to investigate the absorption and radiation spectra of viruses and then subject them to these frequencies. Apparently [13] followed this procedure implicitly, cf. the section on cellular effects. As for enzymes it is not necessary for their activity to change at all frequencies of the absorption spectrum. This applies only to those corresponding to the active centers [77].

In summing up the molecular effects considered above, it can be said that, despite the many obscure aspects of the problem, the biological effects of MW are undoubtedly related to the molecular level of organization of living systems.

The Conditions Required for Manifestation of the Biological Effects of Microwaves

Examination of the methods (insofar as they have been described in detail) used in research on the effects of MW on cellular and molecular structures reveals the following characteristics. An effect is observed only when the temperature of the object is kept constant during irradiation and the duration of irradiation is about 10 minutes or more [17, 18, 20, 22, 28, 28, 30, 31, 34, 39, 51, 53, 56, 57, 78, 79, 80, 1]. In cases where irradiation was continued for a minute or less [41, 47, 82-86] or the object was warmed several degrees or more after irradiation [45, 47, 48, 82], there was no effect ([24, 26] constitute an exception with respect to the duration of irradiation). Mention must also be made of [16, 35, 49, 52, 87] where, despite observance of the necessary conditions, no effect was observed [16, 35] and of the research done for purposes of verification [13, 14, 33]. The negative result [16, 35] was apparently not due to the fact that the research was carried out in the same way. As for [49, 52, 87], the explanation can probably be based on the results of [54].

It may be asked: Why is it necessary (if not always sufficient) for the above-mentioned considerations to be satisfied if an effect is to be observed? Clearly, an effect is due to the realization of some process that requires farily long exposure to radiation. It is difficult at present to say just what this process is. It may be cooperativeness, synchronization of oscillations, a certain kind of excitation, or high-temperature superconductivity. It is interesting to note that Antonowicz [74] also mentions a long period of time. Such time seems to be needed for the field to be able to create some spatial and temporal orderliness in the biological system. The lack of effect when the object is warmed suggested that elevation of the temperature significantly affects the process responsible for altering the functional properties of biological structures. It will be noted that the energy of a quantum of a MW field at a frequency of 3 GHz is equivalent to a change in the energy of thermal motion when the temperature is raised 1°C. It is also possible that warming during irradiation destroys the orderliness created by the field. This situation occurs in thin superconducting bridges when exposed to UHF radiation [88]. But in the case of unidirectional temperature and field actions, the warming effect simply exceeds the field effect (e.g., when enzymes are inactivated by a powerful UHF field). Thus, the warming of an object during irradiation prevents manifestation of the biological effect caused by the direct (electromagnetic) action of microwaves.

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PSYCHOSES IN RADIOWAVE DISEASE

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[Text] Neurosis-resembling and asthenovegetative disturbances in individuals subjected to prolonged action of subthermal powers of superhigh frequency (SHF) radiation, under manufacturing conditions, have been described in reports which deal with radiowave disease (N. V. Tyagin; I. N. Sadchikova and I. V. Glotova; T. N. Orlova and I. V. Chudnovskaya). The property of electromagnetic waves of radiofrequency to evoke structural and functional changes in the central nervous system (M. S. Tolgskaya and Z. V. Gordon; M. I. Yakovleva; Yu. D. Dumanskiy, et al.) allow the possibility that, with a corresponding predisposition, the depth of the mental disturbances in some patients with radiowave disease can attain the level of a psychosis. However, we have found, in the literature, no reference to psychoses arising in connection with the action of radiowave energy.

We have observed three patients with psychoses arising in stages II and III of radiowave disease. All of the patients, over an extended course of time (from 10 to 19 years), had worked in contact with generators of SHF-radiation in the centimeter and decimeter range of great power. One of the patients, in the course of the last 4 years, was exposed, simultaneously, to the action of ultrasound. Often, the patients did not observe the rules of engineering safety; prophylactic medical examinations were not regularly carried out.

The sickness developed in stages. Its first manifestations or marked deterioration of the state of health were preceded by a period of especially intensive work with the apparatus, in the course of which the duration of irradiation by the radiowaves amounted to 10-12 hr and more in 24 hours. There appeared a general weakness, increased fatigue, intensifying at the end of the work day, headaches, increased tendency to perspire, palpitation and pains in the region of the heart, insomnia, irritability. In the course of several years, hyperasthenic and neurasthenia-like disturbances accumulated and became more persistent, not disappearing even at vacation time or in recesses from the job which involved occupational harm. The patients strove to overcome their poor health, having recourse to physicians only in case of extreme necessity. Under examination of the people by internists and neuropathologists, they diagnosed neurosis, vegetative-vascular dystonia, thoracic radiculitis, and so on; the therapy employed had no essential therapeutic effect. Later, in the patients, who were subsequently diagnosed as being in stage III of radiowave disease, there began to appear--along with the asthenic and vegetative disturbances--seizure-like dizziness, sharp headaches, sensation of a "clicking" in the head, convulsive contractions of the muscles, disturbances in coordination of movement and of the "bodily system".

The patients appeared at the psychoneurological dispensary in connection with the psychosis developing in them. Under neurological examination there were delineated moderately pronounced disturbances of oculomotor innervation, nystagmus, asymmetry of the nasolobial folds, deviation of the tongue, increase in tendon reflexes with expansion of reflector areas, unstable pathological Babinski, Oppenheim and Puussepp reflexes, oral automatism, weakening of the abdominal reflexes uncertainty and light, coordinator disturbances on execution of the finger-nose test. All these symptoms were most pronounced in stage III of the radiowave disease.

The EEG revealed diffuse low-amplitude, slow activity and flash-formed alpha waves accompanying a regular alpha rhythm with its normal distribution in all leads. The rheoencephalograms showed venous congestion or manifestations of lowered blood filling of the cerebral vessels. The floor of the eye in two of the patients showed angiopathia of the network of both eyes, dilatation of the venous vessels. X-ray of the skull was without any peculiarities.

Development of the psychosis in all the patients proceeded against a background of severe asthenia and was characterized by prevalence of delirious disturbances. In one of the patients in stage II of the radiowave disease, the first psychotic attack appeared acutely and the clinical picture of it was polymorphic. At the beginning, there developed a hypomaniacal state with lack of concern, talkativeness, non-circumspect and flighty behavior, periods of elevated mood. In donjunction with the increased exhaustion, emotional lability, hyperesthesia, this condition built up into a unique picture of an astheno-maniacal syndrome. Rapidly there were added on flashing symptoms of disturbance of consciousness, of an asthenic jumbled type, accompanied by manifestations of illusory-maniacal derealization, erroneous identifications and elements of mental automatism. At the height of the affective-maniacal attack there was noted a brief episode of oriented oneirism with separate delirium-like hallucinations: the patient was in the center of an unfamiliar city with gardens and large houses, it seemed to him that, along with them was his wife, in the windows of the hospital ward a strange person appeared, and so on. These disturbances of consciousness were not accompanied by psychomotor excitation or catatonic symptoms.

After the completion of the psychotic attack, which lasted a month, there appeared a critical attitude to the disease but with partial amnesia of the experience. In the next stage of the disease, there was retained a stable neurasthenia-like symptomatology, losing, however, the features of hyperesthenia, whose place was occupied by symptoms of asthenic subdepression. Despite recommendations given to him, the patient continued to work in contact with the SHF-irradiation generators and after 3 years, there appeared in him a repeated psychotic attack in whose structure, along with a maniacal mood, there was noted unstable manifestations of mental automatism, arising in direct connection with the hyperesthesia ("as though a nerve adjusts to noise"). Perception of the talking of surrounding people as unbearably loud created in the patient a sensation of its resounding in his head with an experience of "formulation", "mulling over" of an idea.

The further course of the disease appeared in a development of a stable asthenodepressive syndrome, accompanied by psychasthenic disturbances in the form of obstrusive doubts and feelings of constant lack of self assurance. The dysthymia was not accompanied by daily oscillations in mood characteristic of endogenous depression. The patient retained a critical attitude to his mental disturbances, he applied his strength to overcoming the disease.

Two patients in stage III of the radiowave disease displayed psychotic disturbances against a background of clear organic loss of personality with symptoms of euphoria, good humor, accompanied by explosivity and stasis of affect, mild loss of memory and critical attitude towards their own behavior, and a difficult thinking process. What was characteristic was the extreme ease of interpretation of their own disease symptoms, the underestimation of the severity of the disease.

The maniacal disturbances in one patient came on suddenly and were manifested in the form of an acute paranoidal syndrome. Content of an idea, of persecution by a "gang of rogues" clearly reflected the features of the premorbid personality of the patient, his hypersociability, implacable attitude toward lawbreakers. At the height of the interpretive delirium, there arose unstable, transient symptoms of mental automatism with ideas of an action ("somebody nearby in a movie theatre tried to control his thoughts by hypnosis"), of poisoning. The state of anxiety and mild confusion was not accompanied, however, by significant psychomotor excitation, and the patient from the very first days of entry into the hospital engaged in contact with the staff and other patients. The maniacal system appeared quite labile. Even at the height of the mania the patient acknowledged, under the influence of persuasion, the fallibility of his maniacal suspicions although the understanding of their baselessness was unstable and was eroded once again by an influx of new maniacal constructions. The psychotic episode lasted several days; after its conclusion a critical attitude appeared toward the preceding maniacal experience, although it, too, did not have the character of firm conviction. Rather, it was a question of mild and good-humored interpretation by the patient of his maniacal opinions.

In the other patient in stage III of the radioactive disease, maniacal disturbances also appeared to be closely connected with the features of his personality: sthenicity in achievement of a goal; pedantism, egocentrism and a despotic attitude toward family members, with a high degree of adaptation in the work collective and social richness. The pathological sharpening of the traits of character arose under the conditions of work with power generators of SHF-irradiation. As a result of the psychopathization of personality in the initial stage of radiowave disease with manifestation of violent, affective outbursts, there arose a conflict situation in the family and at work with subsequent formation of exaggerated ideas of jealousy. Twelve years after the beginning of the sickness, against a background of accumulating astheno-vegetative disturbances and organic change in personality, the exaggerated ideas were transformed suddenly into a paranoid mania of jealousy with its distinctive behavior and maniacal logic. Accompaniment of the mania by pronounced asthemia and organic change in personality imparted to it a unique tone: along with the affect of spite, irritation, impulsive acts, the patient manifested traits of good nature, mildness in evaluating his family situation. The mania jealousy comparatively quickly lost its static character and acquired a number of the attributes of fixed states. The patient began to complain about the fits of jealousy, he tried to control them, composing, for this purpose, a ritual (a walk, a physically-hard job), he sought help from physicians. However, in contrast to a typical fixation, the patient critically evaluated the sick character of the affective fits, only, those involved in the jealous suspicions, retaining, here, a conviction of his wife's treachery. Here, he didnt try any more to find evidence of the treachery and talked about her to the physician good-naturedly without hard feelings or indignation. As the patient's condition gradually improved, the idea of the wife's treachery lost its acuity and in the first plane in the picture of the disease, along with asthenia there emerged a narrowing in the range of interests, a passive acquiescence to the life situation. However, the patient retained his working capacity, he did his job as brigade foreman in production not involving occupational harm.

Summing up the clinical observations, it is possible to isolate several general traits characteristic of psychoses, involved with prolonged action on the body of radiowave energy. In their structure, these psychoses are endoform, although in none of the described cases of the disease are there data pointing to hereditary predisposition to mental diseases; there is an absence of schizoid traits in the premorbid personality of the patients, and, earlier, before start of work under the conditions of the occupational injuries, there were seen no pathological changes in mental activity, if one doesn't consider accentuation of some traits of character not leading to social disadaptation. The endoform character of the psychosis is most pronounced in the patient in whom the psychotic disturbances arose in stage II of the radiowave disease. With more severe injuries of the central nervous system in stage III of the disease, the psychoses acquire a tinge of the organic.

The most characteristic feature of the psychoses in radiowave disease is their development against the background of a pronounced asthenia. In severe cases, the asthenia reaches degrees of asthenic confusion of consciousness with unstable oneiric inclusions. The basic manifestation of the psychosis is the maniacal disturbances, building up into a picture of an acute paranoidal syndrome or interpretive mania. Accompaniment of the maniacal ideas by the asthenia deprives the mania of traits, inherent in it, of inertia, and the maniacal system appears extremely labile. The asthenia superimposes an impression, also, on the unstable phenomena--arising at the height of the psychosis--of mental automatism, determining its structural connection with asthenic hyperesthesia.

It has to be noted also, that, even in the period of acute mania, the patients strive to get along with surrounding people, establishing with them a productive contact. They acknowledge the fallability of their maniacal interpretations although to speak about their critical attitude to the disease in the full sense of the word is not possible. The absence of unyielding maniacal conviction, sthenicity in the addition of new "proofs" of it, the lability of the psychotic disturbances, impart to the maniacal and affective disturbance a tinge of importunity. Baruk, observing patients with organic psychoses, noted that, despite the confusion of consciousness and the pronounced psychotic disturbances, the patients do not create the impressions of "lunatics". The author explains this as a retention of personality by the patients who are suffering because of their sick disturbances and are fighting them. Precisely about this very attitude of the patients to their disease, it is also possible to speak, with respect to the psychoses induced by the protracted action of subthermal powers of radiowave irradiation.

Observation of patients in the period of development of the psychoses, and, also, remote observation (2-7 years) did not reveal, in the patients, any sort of negative symptoms of disturbance of mental activity characteristic of schizophrenia. The change in personality took the line of its asthenization and, in stage III of the radiowave disease, a moderate organic loss. There were seen, in all patients, expressed, somatic, primarily vegetative-vascular, disturbances characteristic of radiowave disease. However, the severity of their neurological symptoms was greater in comparison with that described for this disease by the author cited above. This once again confirms the connection of the psychoses, arising in radiowave disease, with organic damage of the brain of an encephalopathic type.

Treatment of psychoses in radiowave disease is nonspecific and is determined by the leading psychopathological syndrome and the somatic disturbances. Prophylaxis of these forms of disease comes to early exposure of the symptoms of the radiowave disease and timely suspension of contact with the occupational harmful factors.

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MECHANISM FOR THE EFFECT OF ELECTROMAGNETIC FIELDS ON CARDIAC CONTRACTILE ACTIVITY

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR in Russian No 3, 1980 pp 74-78

[Article by A.A. Samokhina and Z.S. Gurevich, State Medical Institute, Karaganda]

[Text] Abstract. In chronic experiments using polycardiography, a study was made of the myocardial contractile function of the left ventricle of dog hearts after irradiation of different parts of the body (head, heart and chest) by radio-frequency range electromagnetic fields (flux power 20 mW/cm^2). The myocardial contractile function changed in different directions depending on the site affected. Irradiation of the cardiac region reduced the myocardial contractile function, while irradiation of the head and chest increased it. The article examines the mechanisms for this phenomenon.

In the last decade, due to the broad use of electromagnetic energy (increase in the number of radio stations, nuclear power plants, radar units, spacecraft, thermonuclear reactors, etc.), the total electromagnetic "background" of the earth that is created by geophysical and cosmic radiations has significantly increased. All of this forces the body to adapt to a habitat which cannot help but influence the functions of all of its systems. Electromagnetic waves of a certain frequency spectrum (SHF and UHF) are widely used in medicine for a diagnostic and therapeutic purpose.

Analysis of the published data indicates that under the influence of superhigh frequency electromagnetic fields (SHF EMF), in addition to a change in the functions of all the body's systems, the function of the cardiovascular system is changed in people and animals [1-3]. The myocardial contractile function diminishes in people who work for a long time with radar units [4], as well as during a single irradiation of the cardiac region with SHF [5].

Taking into consideration the broad use of SHF EMF in clinical practice and in the industrial sphere, as well as the small amount of information about the shifts in the cardiac contractile function, on which the main indicators of the entire circulatory apparatus depend, we set the goal of investigating the cardiac contractile function during irradiation by a SHF field in experimental conditions.

A study was made of the myocardial contractile function of the left ventricle in chronic experiments on dogs using polycardiography. The duration of the phases of systole and certain other time intervals was computed by synchronous recording of

Table 1. Phase Shifts of Left Ventricle Systole during Irradiation of Right Side of Chest with SHF Field

Index of cardiac cycle, ms	Control (M±m)	Irradiation		
		1	3	5
Cardiac cycle	543±33	581±1.4	614±42	635±31*
Phase of isometric contraction	42±3	36±2	35±3	32±1*
Phase of asynchronous contraction	33±7	36±1	38±1	37±1
Period of stress	75±3	74±2	72±3	71±2
Period of expulsion	156±2	158±3	169±4*	166±5
Mechanical systole	199±3	194±3	205±2*	202±6
General systeole	232±3	232±2	243±2	238±5
Electrical systole	187±3	195±2	206±2*	201±5*
Diastole	310±21	347±15	347±46	401±26
Blumberger's coefficient	2.2±0.1	2.1±0.1	2.1±0.1	2.2±0.1
ISI,%	78.7±1.7	84.4±14	82.7±1.8	85.1±1.6*
Cardiac contraction rate in 1 min	3.7±5.6	104±3	102±7	96±5*

Note. Here and in tables 2 and 3: M--arithmetical mean;m--error of arithmetical mean; the asterisk designates the statistical reliability of the differences (D<0.05).

curves of an electrocardiogram, phonocardiogram and sphygmogram of the carotid artery removed into a skin flap. The photorecording of the curves was done on a four-channel circuit oscillograph.

The time intervals (cardiac cycle, phases of asynchronous and isometric contraction, periods of stress and expulsion, general, mechanical and electrical systole, and ventricular diastole) were computed by the Blumberger-Holdak method in the modification of V. L. Karpman [6].

An additional study was made of the relative amounts that characterize cardiac dynamics: pulse rate, intrasystolic index (ISI) and Blumberger's coefficient.

The SHF field source was the "Luch-2" physical therapy apparatus (wavelength 12.6 cm). The animals were irradiated daily for 10 days with radiation 15 W in power (PPM--20 mW/cm^2) with 10 min exposure. In order to clarify the mechanism for the effect of electromagnetic fields on the cardiac contractile function, we irradiated three sections: right side of chest and head, as the most frequently irradiated sections in physical therapy, as well as the cardiac region for comparative analysis. Two hundred chronic experiments were set up on 20 dogs, and 1400 polycardiograms were interpreted.

As a result of SHF irradiation of the right half of the chest, the cardiac cycle and the phase of asynchronous contraction were lengthened, while the phase of isometric contraction and the period of stress were shortened. The period of expulsion, mechanical, electrical and general sytole, and the diastolic interval lengthened during the irradiation. The indicators that characterize the cardiac

Table 2. Shifts in Phses of Systole of Left Ventricle during Irradiation of Heart by SHF Field

Indicator of cardiac cycle, ms	Control (M±m)	Irradiation		
		1	4	6
Cardiac cycle	543±23	544±19	571±27	562±15
Phase of isometric contraction	42±3	37±5	56±6*	57±5*
Phase of asynchronous contraction	33±7	34±1	35±3	32±1
Period of stress	75±3	71±5	91±5*	89±9*
Period of expulsion	156±2	167±7	143±4*	142±3*
Mechanical systole	199±3	196±3	198±3	200±3
General systeole	232±3	229±3	236±4	243±5*
Electrical systole	187±3	180±3	179±2*	174±4*
Diastole	310±21	338±10	341±20	326±12
Blumberger's coefficient	2.2±0.1	2.8±0.5	1.5±0.1*	1.6±0.1*
ISI,%	78.7±1.7	81.5±2.7	72.1±2.7*	71.6±2.0*
Cardiac contraction rate in 1 min	3.7±5.6	105±2	102±4.3	107.5±3.6

dynamics, in particular the intrasystolic index and Blumberger's coefficient, increased. These deviations were the maximum after 3-5 irradiations (table 1). They characterized the hyperdynamic syndrome, i.e., intensification in the contractile function of the heart. This is indicated by a shortening in the phase of isometric contraction (rapid increase in the rate of rising in intraventricular pressure) and lengthening of the expulsion phase [6].

It seems to us that the mechanism for increase in the myocardial contractile function is the following. The SHF effect causes an intensification of the blood influx to the heart from the pulmonary veins through the reflexogenic zones of the lungs, thus increasing the systolic discharge (Starling's mechanism). Such shifts are possible in pressor cardiovascular reflexes [7]. The effect of hyperfunction is also associated with humoral factors. This is indicated by shifts in the phase of asynchronous contraction [8].

Irradiation of the heart region caused two-phase shifts in the myocardial contractile function. After the first irradiation there was a tendency towards shortening of the phase of isometric contraction, lengthening of the expulsion period, shortening of the electrical systole, and increase in the intrasystolic index. This characterizes the increase in the myocardial contractile function. After 3-4 irradiations (table 2), the second phase of the reaction to SHF irradiation appeared: the cardiac cycle, mechanical and general systole, ventricular diastole, the phase of isometric contraction and the period of stress lengthened on the background of a shortening in the stage of expulsion with a drop in Blumberger's coefficient and the ISI. This was accompanied by bradycardia, a decrease in the systolic volume of the heart with a decline in the systems arterial and venous pressures and a drop in the pulse pressure [9]. This characterizes the weakening of the myocardial contractile function.

It seems to us that the dynamics for the shifts in myocardial contractile function are the following. The initial reaction of intensified myocardial contractile function is linked to the nonspecific cardiac reaction, as for any other stimulus. It involves the hypophyseal-adrenaline system and an increase in the tone of the sympathetic innervation centers. Then after 3-6 irradiations, the contractile

Table 3. Shifts in Phase of Left Ventricle Systole during Irradiation of the Head with SHF Field

Indicator of cardiac cycle, ms	Control (M±m)	Irradiation		
		1	3	5
Cardiac cycle	543+23	676±22	687+22	702+33
Phase of isometric contraction	42±3	46±5	41±2	39±3
Phase of asynchronous contraction	23±7	36±1	36±2	38±1
Period of stress	75±3	77±5	77±5	77±5
Period of expulsion	156±2	162±4	171±5	161±8
Mechanical systole	199±3	202±4	213±3*	202±5
General systole	232±3	243±4*	250±5*	247±5*
Electrical systole	187±3	194±4	178±2*	187±5
Diastole	310±21	412±21*	436±29*	454±22*
Blumberger's coefficient	2.2±0.1	1.9±0.1	2.2±0.1	2.0±0.1
ISI,%	78.7±17	80±2.5	80.3±1.9	79.2±2.2
Cardiac contraction rate in 1 min	3.7±5.5	98+2	89.5±7.1	85.6±4.1

function is reduced, apparently due to dystrophic shifts in the myocardium. This is indicated in our studies by the shifting in the ST interval, the expansion of QRS complex, the negative T projection, and reduction in the voltage of all the projections on the electrocardiogram.

Irradiation of the head, on all days of irradiation lengthened the cardiac cycle, the general systole, the period of expulsion and the ventricular diastole with maximum shifts on the 3-5 day (table 3).

Thus, the nature and pronouncement of the SHF effect on the myocardial contractile function depended on the irradiated region. Irradiation of the heart yielded a two-phase reaction: the increase in cardiac contractile function (after 1-2 irradiations) was replaced by the hypodynamic syndrome (after 3-5 irradiations). Since the reduction in contractile function was noted after multiple irradiation of the heart, we link this to dystrophic processes in the actual cardiac muscle. Irradiation of the right side of the chest increased the myocardial contractile function from the second day of irradiation with normalization on the 10th day. The effect of the SHF field on the head increased the myocardial contractile function from the first to 10th day with certain quantitative oscillations in the intervals (the increase could be replaced by normalization, then again by an increase in the function).

Cardiac irradiation induced shifts immediately at the moment of irradiation, while irradiation of the head and chest induced shifts in 5-15 min after it. The reaction was maintained for more than a day after irradiation of the head and heart, and about an hour after irradiation of the right side of the chest.

The mechanism for the increase in the myocardial contractile function during irradiation of the right side of the chest by a SHF field is apparently based on Starling's mechanism. It is associated with a rising influx of blood to prolonged diastole, and during irradiation of the head it is linked to a change in the tone of the autonomic cardiac innervation center.

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EFFECT OF UHF ELECTRICAL FIELD ON THE BLOOD COAGULATION SYSTEM IN ANIMALS

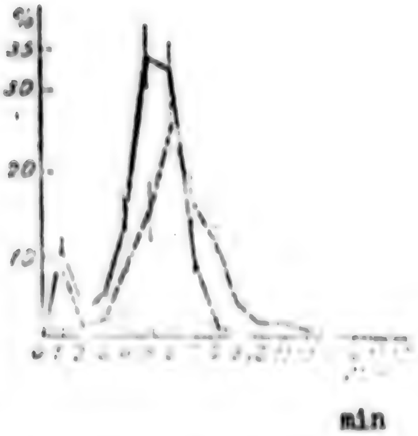
Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY
in Russian No 4, 1976 pp 76-79

[Article by V. F. Rusyayev and G. I. Mulyndina, Department of Physics, Chita Medical Institute]

[Text] The experiments were set up on 18 rats; 8 of them served as the control. The experimental animals were placed in a special chamber made of organic glass and they were exposed to a UHF electrical field with intensity of the electrical component 80 v/m for 10 days of 5 min daily. Then, with the help of heart puncture blood was obtained and stabilized with sodium oxalate (9:1). Part of the blood was used to determine the ESR [erythrocyte sedimentation rate], content of hemoglobin, erythrocytes and leukocytes, viscosity, as well as the acid resistance of the erythrocytes (I. I. Gitel'zon and I. A. Terskov). The remaining blood was centrifuged at 3000 rpm for 5 min to obtain plasma with a low blood platelet count. This substrate was further used to study the recalcification time (Bergerhof and Roka), thrombin time (Sirman), prothrombin consumption (M. A. Kotovshchikova and Z. D. Fedorova), and fibrinolytic activity (Kowarcyk and Buluk) in the blood plasma of the control and experimental animals, as well as the effect of the tissue extracts on the coagulating indices.

The tissue extracts were prepared from the anterior wall of the left ventricle and the aorta. For this, the tissue fragments were thoroughly washed of blood, dried by a decalcified filter, weighed on analytical scales, and pulverized in a porcelain mortar with a physiological solution. The homogenized substrate was further diluted 30,100, 1000 and 10,000 times and used in the experiments.

Under the influence of the UHF electrical field, the hemoglobin content in the rats dropped to 11.4±0.3% (in the control 12.9±0.5%; $D<0.05$), ESR rose to 7.6±1.8 mm Hg (in the control 2.6±0.2 mm Hg; $D<0.02$), blood viscosity was reduced to 3.6±0.1 cP (in the control 4.2±0.3 cP; $D<0.1$), the number of erythrocytes dropped to 5.4±0.4 million in 1 mm^3 of blood (in the control 6.4±0.7 million; $D<0.2$), and the number of leukocytes increased to 4800±510 in 1 mm^3 of blood (in the control 3900±460; $D<0.2$).



Acid Erythrograms before (dotted line) and after (solid line) Exposure to UHF Electrical Field

Consequently, both the white and the red blood reacted naturally to the effect of the employed physical factor. A reliable acceleration in the ESR and decrease in the hemoglobin level were found; a trend was noted towards a reduction in viscosity, content of erythrocytes, and certain increase in the content of leukocytes. Apparently, the change in the erythrocyte content stipulates the reduction in viscosity. At the same time a decrease was noted in the resistance of the erythrocytes (see figure).

As is apparent from tables 1 and 2, the effect of the UHF electrical field induces pronounced changes in the blood coagulation system, which is manifest in the sure increase in the thromboplastic activity of the plasma (diminishing in the recalcification time, increase in the utilization of prothrombin). The hypercoagulation shift is indicated also by the rise in antiheparin activity. In conducting these studies, we did not succeed in establishing the reliable influence of the physical factor on the lysing capacity of the blood.

An investigation of the tissue extracts makes it possible to draw the conclusion that the aorta and heart contain thromboplastin whose activity is manifest even with dilution of 1:10,000. In addition, the studied tissues revealed an antiheparin substance, as well as substances that stimulate fibrinolysis. Attention is drawn to the fact that the tissue extracts obtained from the aorta have a more pronounced effect on the coagulation and fibrinolytic indicators than the extract from the heart.

The UHF electrical field induces a reliable drop in the coagulation activity of the tissue extracts of both the aorta and the heart. Here, there is a rise in the recalcification time, a drop in the consumption of prothrombin, and fibrinolysis is delayed. One should note that in the myocardium the antiheparin activity is considerably reduced, while in the aorta it is somewhat increased.

Table 1. Effect of UHF Electrical Field on Coagulation Indices of Aorta Extracts

(1) Показатель	(2) Контроль					(3) Опыт				
	(4) субстратная плазма	1:30	1:100	1:1000	1:10 000	(4) субстратная плазма	1:30	1:100	1:1000	1:10 000
R	97	13	16	31	55	66	14	18	34	59
A		86	84	68	43		78	73	48	10
±m	12,8	0,7	1,0	1,5	1,9	4,7	0,7	0,8	1,2	1,8
P_1 D1		<0,01	<0,01	<0,01	0,01		<0,01	<0,01	<0,01	<0,01
P_2 D2						<0,05	<0,3	<0,2	<0,3	<0,1
ПП	107	1200	771	374	169	172	818	650	303	154
A		1020	600	274	58		375	280	71	—16
±m	18,0		35,0	23,0	7,4	19,0	48,0	31,0	19,0	5,8
P_1 D1		<0,01	<0,01	<0,01	<0,01		<0,01	<0,01	<0,01	—
P_2 D2						<0,05	<0,01	<0,05	<0,05	<0,1
T	45	27				42	21			
A		40					50			
±m	0,8	1,3				0,7	1,8			
P_1 D1		<0,01					<0,01			
P_2 D2						<0,05	<0,05			
Φ	215	158				213	183			
A		26					12			
±m	19,0	9,0				22,0	11,0			
P_1 D1		<0,01					<0,3			
P_2 D2						—	<0,05			

Key:

Here and in table 2

1. Indicator
2. Control
3. Experiment
4. Substrate plasma

R. Recalcification time (in s)

ПП. Prothrombin consumption (in s)

T. Thrombin time (in s)

Φ. Fibrinolytic activity (in min)

A. Change in indices in relation to substrate plasma (in %)

Statistical processing was done between the indices of the substrate plasma and the extracts (D_1), and between the corresponding data in the control and in the experiment (D_2).

The cited data make it possible to consider that the UHF electrical field induces hypercoagulation, and also suppresses the thromboplastic and fibrinolytic capacity of the tissue extracts for blood coagulation. It is the most real to hypothesize that the mechanism "responsible" for the observed shifts is based on the capacity of the UHF electrical field to alter the structure of the cellular membranes.

Table 2. Effect of UHF Electrical Field on Coagulation Indices of Myocardial Extracts

(1) Показатель	(2) Контроль					(3) Опыт				
	(4) [illegible]	1:30	1:100	1:1000	1:10 000	(4) [illegible]	1:30	1:100	1:1600	1:10 000
R	97	54	31	52	63	[illegible]	54	[illegible]	55	60
A		51	[illegible]	49	38		5	[illegible]	15	−5
±m	12,7	0,9	[illegible]	2,5	[illegible]	[illegible]	0,4		1,5	[illegible]
P_1 D_1		<0,0[illegible]	<[illegible]	<[illegible]	<[illegible]		<0,[illegible]	<	<[illegible]	<[illegible]
P_2 D_2						<[illegible]	—	<	<[illegible]	<[illegible]
[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
A		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	
±m		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]
P_1 D_1		<0,01	<[illegible]	[illegible]	<[illegible]		<0,[illegible]	<	<0,1	—
P_2 D_2						<0,05	<0,[illegible]	<0,2	<0,02	<0,2
T	45	25				42	32			
A		45					24			
±m	0,8	0,7				0,7	2,7			
P_1 D_1		<0,01					<0,01			
P_2 D_2						<0,05	<0,05			
Φ	215	121				213	147			
A		43					31			
±m	19,0	2,9				22	9,4			
P_1 D_1		<0,01					<0,02			
P_2 D_2						—	<0,02			

As is known, the "skeleton" of these formations is the bimolecular layer of lipids bonded to protein. Among the phospholipids that are included in the composition of the cellular membrane, there are substances that have a pronounced thromboplastic effect (phosphatidilethanolamine, phosphatidilcholine, phosphatadilserine). Now it has been established that some of the phospholipids are not strongly bound to each other (Sechs et al). Probably, the UHF electrical field as a result of the polarization effects promote the discharge of these substances from the tissues, after which they enter the bloodstream. The suggested mechanism explains the increase in thromboplastic activity of the blood and the decrease in the coagulating ability of the tissue extracts in the experimental animals.

We established previously that the UHF electrical field promotes the release of thromboplastin from the formed blood components. Other authors who have studied the effect of electromagnetic factors on nerve tissue (Yu. M. Ir'yanov) and thrombocytes (Abbozzo) have come to the conclusion that it is capable of isolating phospholipids from the cellular membrane. All of this indicates the competence of the suggested hypothesis. Finally, an indirect confirmation of the discharge of tissue factors is the acceleration of the ESR, an index that is in close interrelationship with the content of blood lipids (Böttiger), as well as the slightly pronounced leukocytosis. It is possible that the reduction in erythrocyte resistance under the influence of the UHF electrical field, and the suppression of the tissue fibrinolytic agents is linked to analogous processes.

The data we obtained make it possible to consider that the biological effects of the UHF electrical field are realized not only through the regulatory systems (nerve and humoral), but are also governed by its direct effect on the structural components of the cell itself.

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SIGNIFICANCE OF BLOOD LIPID AND ELECTROLYTE DISTURBANCES IN THE DEVELOPMENT OF SOME REACTIONS TO MICROWAVES

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 2, 1980 pp 38-39

[Article by M.N. Sadchikova, S.F. Kharlamova, N.N. Shatskaya and N.V. Kuznetsova, Institute of Industrial Hygiene and Occupational Diseases, USSR Academy of Medical Sciences]

[Text] Recent studies have shown that occupational pathology resulting from exposure to microwaves of considerable intensity (several milliwatts per cm^2) is manifested by changes in the nervous and cardiovascular systems. Data have been obtained on autonomic vascular shifts and hypertension after exposure to microwaves of low intensity, of the order of several hundred microwatts per cm^2 (G.G. Lysina; M.N. Sadchikova et al.).

We analyzed blood lipid and electrolyte levels in persons who had been working with sources of microwaves of low intensity for a long time. We observed 50 industrial workers who were subjected to intermittent local (chiefly, the hands, head, and upper part of the body) microwave irradiation at an intensity of about several hundred microwatts per cm^2) in the course of regulating, adjusting, and testing radars in radar production shops and in sectors performing final calibration. The duration of irradiation during a work shift was no more than 2 to 3 hours (K.V. Nikonovaya and I.P. Sokolovaya). Among other unfavorable factors associated with work in the compartments of the radar stations were the high ambient temperature (about 37 to 39° C and relative humidity of 30 to 40 percent) and noise which did not exceed hygienic standards. The subjects ranged in age from 32 to 50 years, with 42 years the average. Their work experience varied from 5 to 15 years, with 13 years the average.

Physical examination of the subjects revealed some autonomic vascular changes: bright red, diffuse, persistent dermographia, hyperhidrosis, unstable pulse and blood pressure with a tendency to hypertension and abnormal cardiac activity (cardialgia, change in conduction, high acute apex T-wave or small decrease in the T-wave chiefly in the thoracic leads). Systolic and diastolic pressures were unstably high: 140 to 150/90 mm in three-fourths of the subjects and 160/100 mm or higher in the others. They were associated with mild arterial constriction and dilatation of veins and, in some individuals, with angiopathy or sclerosis of retinal blood vessels (E.N. L'vovskaya). Controls were 79 apparently healthy men similar to the others in age and field of specialization but not exposed to unfavorable environmental factors.

The following parameters were determined: plasma and RBC sodium and potassium levels by flame photometry, sodium and potassium membrane gradients Na_{rbc}/Na_{pl} and K_{rbc}/K_{pl})

from the ratio of intracellular sodium and potassium to the extracellular ions, chlorides in whole blood by Levinson's method, cholesterol by Bloor's method, lipid phosphorus by Starosel'skiy's method, phospholipid/cholesterol ration, beta lipoproteins by Burstein's method as modified by M. Ledvin, and triglycerides by Neri's methods. The results were processed statistically. The limits of fluctuation of the arithmetic mean ($M \pm 1.5\sigma$)obtained in the control group were taken as the normal parameters. The data obtained in the control group were consistent with the literature.

The individuals working with sources of microwaves (main group) revealed disturbances of some parameters of blood electrolytes. There was a statistically significant decrease in the means of the chlorides and intracellular sodium in comparison to the controls. Blood chloride levels dropped to 275-380 mg percent (393 mg percent the lower limit of normal) in 67.6 percent of cases. The concentration of intracellular sodium shifted in almost all those examined toward the lower limit of normal (31.9 mg percent). A decrease in concentration of intracellular sodium was also suggested by the change in Na_{rbc}/Na_{pl} = 0.12 vs 0.14 in the controls. Hyponatriemia was accompanied by a lowering of the blood chloride level. The mean potassium concentration in the red blood cells was lower than the control but the differences were not statistically significant. The values of the potassium gradient also remained unchanged.

An investigation of blood lipids disclosed in the main group a statistically significant increase in the mean values of the triglycerides, beta lipoproteins, cholesterol and phospholipids. The triglycerides and beta lipoproteins changed the most. The blood triglyceride levels rose in 63.6 percent of cases to 157-259 mg percent with 151 mg percent the upper limit of normal.

Beta lipoprotein concentrations increased in 50.2 percent of cases, ranging from 783 to 1659 mg percent. A comparison of the values of the beta lipoproteins with the blood pressure did not show any clear-cut parallels ($\chi^2 = 1.59$, $P > 0.05$). On the other hand, a direct relationship was found between hypobetalipoproteinemia and retinal angiopathy ($\chi^2 = 6.2$, $P < 0.01$).

Our studies showed that workers exposed for a long time to microwave radiation of low intensity of the order of several hundred microwatts per cm^2 as the principal adverse industrial environmental factor exhibited some autonomic vascular changes, hypertension, elevation of triglyceride, beta lipoprotein, and cholesterol levels, and decrease in concentration of chlorides and intracellular sodium. Hyperlipidemia, particularly hyperbetalipoproteinemia, differed significantly from that in the controls of the same age and it was directly related to the clinical manifestations. Hyponatriemia was associated with hypochloridemia. Presumably, the clinical manifestations and the change in concentration of blood lipids and electrolytes in individuals handling sources of microwaves of low intensity were caused by a disturbance of neurovascular and humoral regulation due to exposure to microwaves. Besides higher nervous activity, which is responsible for the central regulation of metabolism and vascular tone, atherosclerosis plays a considerable role in the development of hypertension (D.F. Chebotarev). The disturbance of lipid metabolism, especially that of triglycerides, is a major factor in the pathogenesis of atherosclerosis (L.V. Kasatkin et al.; T.S. Yanushkens; Havel).

The presence of high concentrations of blood lipids, including beta lipoproteins and triglycerides, after long exposure to microwaves of low intensity suggests that such radiation can be regarded as a factor predisposing to the development of atherosclerosis. It is quite possible for hypertension in such individuals to be combined with atherosclerosis because the two diseases are closely interrelated. Epidemiological research is needed to deal with this important matter as well as with the widespread clinical manifestations.

Conclusions

1. Individuals long exposed to microwaves ot low intensity (of the order of several hundred microwatts per cm^2) exhibit some autonomic vascular changes, symptoms of hypertension, elevation of blood triglyceride, beta lipoprotein, cholesterol, and phospholipid levels, and decrease in concentration of chlorides and intracellular sodium.

2. The elevation of blood lipid levels suggests that microwave radiation is a risk factor predisposing to the development of atherosclerosis. It should be borne in mind by those planning measures to prevent cardiovascular disease in the occupational groups exposed to microwaves.

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CALCIUM AND MAGNESIUM CONCENTRATIONS IN THE TISSUES OF RATS EXPOSED TO AN ELECTROMAGNETIC FIELD OF INDUSTRIAL FREQUENCY

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 2, 1980 pp 46-47

[Article by V.D. Dyshlovoy, Z.T. Radlovskaya, V.D. Arkhipchuk and V.S. Kachura, A.A. Bogomolets Institute of Medicine, Kiev]

[Text] The purpose of our work was to study ion metabolism, specifically, calcium and magnesium concentrations in the tissues and organs of animals exposed to an intense electromagnetic field of industrial frequencies.

Procedure

Experiments were performed on mature male Wistar rats weighing 180 to 200 g. One control and one experimental animal were studied at the same time. A total of 7 pairs of animals were studied. The experimental rats were exposed to an electromagnetic field at a frequency of 50 Hz and voltage of 50 kV/m for 5 hours. The animals were decapitated immediately afterward.

The calcium and magnesium concentrations were determined in the following way. Batches of tissue (100 to 200 mg) were dried at 80° C in a desiccator to a constant weight and then ashed in porcelain crucibles in a baffle oven at 500 to 650° C (L.L. Grechishkin and K. Ritling). The ash residue was dissolved in 3 ml of 3 N HCl. An aliquot of 1 ml was brought to a volume of 50 ml with 0.36 N HCl. Lanthanum chloride was added to the solution until it reached a concentration of 0.01 mg/ml. The metal content of the samples was determined with an atomic absorption S-302 spectrophotometer adjusted to the resonance lines 4227 and 2852 Å to assay calcium and magnesium, respectively. The magnesium and calcium concentrations were estimated from a calibration curve in micrograms per gram of dry tissue mass.

Results and Discussion

The calcium and magnesium concentrations were determined in 15 tissues and organs of the control and experimental animals (table). After 5 hours' exposure to the electromagnetic field, certain tissues showed a decrease in the calcium and magnesium concentrations while others showed an increase. A significant (approximately twofold) decrease was noted in the liver and thymus. A significant (more than twofold) increase was found in the brain, testes, prostate, and lingual and femoral muscles. The calcium concentration decreased significantly in the kidneys while the magnesium concentration did so insignificantly. No significant changes were found after exposure to the electromagnetic field in the heart, lungs, stomach, spleen, large and small intestines, or adrenals.

The differences in the reaction of the various organs may be attributed to the electrical properties of the tissues in question, to the dissimilar functioning of the organs, and to the intensity of the homeostatic parameters.

Our data can be regarded as evidence that an electromagnetic field of industrial frequency exerts a biological influence, especially on ion metabolism.

Содержание кальция и магния (в мкг на 1 г сухой массы) в тканях крыс после 5-часового воздействия электромагнитного поля частотой 50 Гц и напряженностью 50 кВ/м (M ± m; n = 7)

Объект исследования (1)	(2) Кальций		P	Магний (5)		P
	контроль (3)	опыт (4)		контроль (3)	опыт (4)	
(6) Печень	3534±485	1781±309	<0.001	1565±90	1223±57	<0.001
(7) Тимус	5202±621	2863±322	<0.01	2381±175	1484±152	<0.01
(8) Почки	1376±190	3016±890	<0.05	1269±137	1328±84	>0.1
(9) Мозг	1367±205	3347±807	<0.001	901±78	1362±12	<0.001
(10) Мышцы бедра	693±151	2906±295	<0.001	1321±102	1731±139	<0.05
(11) » языка	916±206	2831±604	<0.01	818±134	1266±75	<0.01
(12) Семенники	1526±426	4945±969	<0.01	1426±338	2042±121	<0.05
(13) Предстательная железа	1053±215	2157±318	<0.001	721±49	974±72	<0.01
(14) Сердце	2937±519	2287±100	>0.1	1286±70	1091±13	>0.1
(15) Легкие	3947±104	3132±786	>0.1	1456±163	1494±122	>0.1
(16) Желудок	2003±372	2735±771	>0.1	558±82	865±75	>0.1
(17) Селезенка	1769±367	2548±838	>0.1	1396±97	1451±116	>0.1
(18) Толстая кишка	2188±503	4425±913	>0.1	1244±11	1498±16	>0.1
(19) Тонкая »	2428±534	2202±408	>0.1	1575±16	1507±86	>0.1
(20) Надпочечники	2557±538	3118±109	>0.1	868±124	877±39	>0.1

Calcium and Magnesium Concentrations (in μg per g of dry weight) in Rat Tissues After 5 Hours' Exposure to an Electromagnetic Field at a Frequency of 50 Hz and Voltage of 50 kV/m (M±m; n=7)

Key:

1.	Object investigated	11.	Lingual muscles
2.	Calcium	12.	Testes
3.	Control	13.	Prostate
4.	Experiment	14.	Heart
5.	Magnesium	15.	Lungs
6.	Liver	16.	Stomach
7.	Thymus	17.	Spleen
8.	Kidneys	18.	Large intestines
9.	Brain	19.	Small intestines
10.	Femoral muscles	20.	Adrenals

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SPECIAL FEATURES OF CARBOHYDRATE-ENERGY AND NITROGEN METABOLISM IN THE RAT BRAIN UNDER THE INFLUENCE OF MAGNETIC FIELDS OF COMMERCIAL FREQUENCY

Kiev UKRAINSKIY BIOKHIMICHESKIY ZHURNAL in Russian No 3, 1980 pp 299-303

[Article by F.A. Kolodub and O.N. Chernysheva, Khar'kov Scientific-Research Institute of Labor Hygiene and Occupational Diseases]

[Text] A study was made of the effect of alternating magnetic fields of commercial frequency, depending on the intensity and regime of generation, on carbohydrate oxidation, linkage of oxidation to phosphorylation and the level of nucleic acids in the brain tissue.

It was established that the repeated (15 sessions) action of an uninterrupted alternating magnetic field of an intensity of 32 kA/m brings about a reduction in the level of glycogen, creatine phosphate, intensity of respiration and esterification of inorganic phosphate, glutamine content and increase in DNA content. An uninterrupted alternating magnetic field of an intensity of 32 kA/m does not influence the studied indicators of metabolism in the brain, while an intermittent magnetic field (duration of impulse 1 s, interimpulse interval 2 s) of the same intensity and exposure causes a reduction in the content of glycogen, glucose, creatine phosphate, RNA and DNA and activates oxidation processes and increases their conjugation with phosphorylation.

Literature data [1, 2] attest to a significant, depending on the physical param [illegible] influence of alternating magnetic fields of commercial frequency (50 Hz) [illegible] the functional state of the central nervous system. The biochemical mechanisms existing at the basis of these changes have practically not been investigated. Nonetheless their elucidation is most necessary for the study of pathogenetic prevention and therapy.

In assuming that an alternating magnetic field affects the organism first of all by influencing energy metabolism, it seemed feasible to study the state of individual elements of carbohydrate metabolism [3] and also the metabolsim of nitrogen low-molecular compounds [4] of nucleic acids [5] during the action of alternating magnetic fields on the organism, which was the objective of our research.

Materials and Methods

The subject of investigation was 240 non-pedigreed white male rats with a mass of 160-180 g, subjected to repeated (15 sessions) and chronic (three or six months) action of an alternating magnetic field under uninterrupted and intermittent (duration of impulse 1 s and interimpulse interval 2 s) regimes of generation with an intensity of 32 and 7.5 kA/m with a daily exposure of 5 and 3 hours, respectively.

Twenty hours after the experimental and control animals, taken for determination of the state of intermediary metabolism, were irradiated for the last time, they were decapitated; the heads were then immediately frozen in liquid nitrogen, following which the brain tissue was removed from the cranium, ground into powder and was used to determine the content of glycogen, glucose, piroracemic and lactic acids [6], creatine phosphate [7], ammonia, glutamine [8], nitrogen amide [amidnyy azot] of proteins [9], RNA and DNA [10].

The ATP content and its dephosphorylated derivates--ADP and AMP--were determined with the help of high-voltage paper electrophoresis, using the basic procedures described by Sato et al. [11] and Voskoboynikov [12]. They achieved a clear-cut separation of tri-, di- and monophosphates of adenosine by using a citrate buffer (pH 3.8) containing 0.001 M of zinc acetate as a stabilizer of ATP during the time of separation (3.5.-4 hours) with a gradient of 15 V/cm.

The state of oxidizing phosphorylation was judged by determining the intensiveness of oxygen absorption by the brain tissue and esterification of inorganic phosphate [13]. There was used as an oxidation substrate α-ketoglutarate (0.013 M); respiration intensity was determined manometrically in a Barburg apparatus with an air atmosphere at 26°C for the duration of 20 minutes. The content of inorganic phosphate was determined with the method used by Lowry and Lopez [14] and modified by Peel and Loughman [15]. At the same time, for the purpose of more precise determination of the direction and degree of activity of individual elements of metabolism in the homogenates of the brain tissue, there was determined spectrophotometrically the activity of hexokinase (KF 2.7.1.1) [16], glucose-6-phosphate dehydrogenase (KF 1.1.1.49) [17], lactate dehydrogenase (KF 1.1.1.27) [18], succinate dehydrogenase (KF 1.3.99.1) [19], cytochrome oxidase (KF 1.9.3.1) [19], ribonuclease (KF 2.7.7.16) and desoxyribonuclease (KF 3.1.4.6) []0]. The obtained data were treated statistically and were considered reliable when $p<0.05$.

Results and Discussion

In tissue of the brain of rats subjected to repeated action of an alternating magnetic field with an intensity of 32 kA/m, a reduction was observed in the content of glycogen (table 1). As is known, this can equally attest either to activation of aerobic and anaerobic glycolysis [21] or to slowing down of the processes of gluconeogenesis [22].

The absence of changes in the level of lactic and piroracemic acids and also in hexokinase, glucose-6-phosphate dehydrogenase activities makes it possible to assume that the intensity of glycolysis and pentose phosphate cycle does not change. At the same time a reliable reduction (16 percent on the average) of intensiveness of consumption of oxygen, disclosed against the background of a change in cytochrome oxidase and succinate dehydrogenase activity, nevertheless may indicate slowing down in the utilization of carbohydrates in nerve tissue.

Consequently, the reduction in the level of glycogen noted under the influence of a magnetic field with an intensity of 32 kA/m is most probably due to a slowing down of the processes of glyconeogenesis.

It should be emphasized that with the 20-percent reduction in the consumption of oxygen there was a simultaneous reduction in the intensity of esterification of inorganic phosphate. This points to the retention in the experimental animals of the conjugation of the processes of oxidation with phosphorylation (the P/O coefficient compared to the control does not change) within the limits of the control magnitudes.

But the simultaneous reduction in the volume of both intensity of oxidizing processes and in the processes of phosphorylation linked with them brings about a deficit of macroergic compounds, particularly creatine phosphate.

A certain interest is also presented by the data obtained in the determination of the level of certain nitrous metabolites, especially nucleic acids. As can be seen from table 1, with the action of an alternating magnetic field with an intensity of 32kA/m, the glutamine content in the studied tissue is reliably reduced, moreover, against the background of an absence of changes in ammonia level, which makes it possible to assume an absence of the alternating magnetic field influencing processes of amidation or deamidation of glutamine. It is possible that in addition to the other causes of the reduction in the glutamine level is due to an increase in its use for the synthesis purine bases [23]. Such a supposition seems probable, since the DNA level rises under the influence of the alternating magnetic field. The concrete mechanisms of this occurrence require special research. Nonetheless, taking into account the lack of changes in the activity of DNA-ase, it may be supposed that the rise of the DNA content in the brain tissue of the irradiated rats was most probably due to an intensification of the processes of its biosynthesis rather than to retardation of degradation.

Table 1. Effect of Repeated Action of Uninterrupted Alternating Magnetic Field on the State of Metabolism and Enzyme Activities in the Brain Tissue of Rats (Average Data for 8-12 Observations (M±m)

Studied Parameters	Control	Experiment	ρ
Content of glycogen, mg%	106.1±11	71.9±7.1	<0.05
lactic acid, mg%	37.9±2.8	33.4±4.1	>0.05
piroracemic acid, mg%	1.67±0.12	1.95±0.23	>0.05
Hexokinaseactivity, micromole of NAD P-H$_2$ per 1 mg of protein for 1 hr	0.546±0.021	0.533±0.024	>0.05
Glucose-6-phosphate dehydrogenase activity, micromole of NAD P-H$_2$ per 1 mg of protein for 1 hr	0.103±0.008	0.090±0.007	>0.05
Lactate dehydrogenase activity, micromole of pyruvic acid per 1 g of tissue for 1 hr	190.1±1.1	189.9±0.8	>0.05
Creatine phosphate content, mg%	31.7±3.4	25.7±1.9	$0.05<\rho<0.1$
Consumption of O$_2$, microatoms of O$_2$ per 100 mg of tissue for 1 hr	7.56±0.34	6.37±0.34	<0.05
Consumption P$_1$, microatoms of P$_1$ per 100 mg of tissue for 1 hr	14.9±0.72	12.0±0.99	<0.05
P/O coefficient	1.96±0.08	1.87±0.14	>0.05
Succinate dehydrogenase activity, ΔE_{550} per 1 mg of protein for 1 hr	6.2±0.54	6.4±0.9	>0.05
Citochrome oxidase activity, ΔE_{550} per 1 mg of protein for 1 hr	14.9±1.1	16.3±1.0	>0.05
Content of			
ammonia, mg%	0.73±0.07	0.65±0.07	>0.05
glutamine, mg%	6.77±0.18	5.84±0.33	<0.05
DNA, mg%	8.5±0.4	10.5±0.6	<0.02
DNA-ase activity, ΔE per 1 g of tissue for 1 hr	5.4±0.27	4.9±0.22	>0.05
RNA-ase activity, ΔE per 1 g of tissue for 1 hr	0.96±0.1	0.915±0.05	>0.05

It should be noted that the indicated changes in metabolism in brain tissues occurred during the operation of the noninterrupted alternating magnetic field with an intensity of 32 kA/m and were practically not observed in any of the periods (15 sessions, three and six months) of operation of the field with an intensity of 7.5 kA/m.

Under the influence of the alternating magnetic field with an intensity of 7.5 kA/m in an intermittent regime of modulation, deviations in the level of the investigated intermediary products of metabolism and enzyme activities are observed (table 2). As under the influence of an uninterrupted

Table 2. Influence of Repeated Action of Intermittent Alternating Magnetic Field on the State of Metabolism and Enzyme Activities in the Brain Tissue of Rats (Average Data for 7-14 Observations) (M±m)

Studied Parameters	Control	Experiment	
Content of			
glycogen, mg%	72±2.5	51.6±3.4	<0.001
glucose, mg%	29.5±2.6	19.3±2.2	<0.01
lactic acid, mg%	47.2±3.5	45.5±3.0	>0.05
Hexokinase activity, micromole of NAD P-H$_2$ per 1 mg of protein for 1 hr	0.455±0.222	0.400±0.022	>0.05
Glucose-6-phosphate dehydrogenase activity, micromole of NAD P-H$_2$ per 1 mg of protein for 1 hr	0.173±0.006	0.178±0.008	>0.05
Lactate dehygrogenase activity, micromole of piroracemic acid per 1 mg of protein for 1 hr	38.8±2.4	41.5±2.8	>0.05
Content of			
creatine phosphate, mg%	45.3±2	38.8±1.3	<0.02
ATP+ADP, micromole per 1 g of tissue	2.6±0.08	2.6±0.14	>0.05
AMP, micromole per 1 g of tissue	0.44±0.06	0.58±0.1	>0.05
Consumption of O$_2$, microatoms of P per 100 mg of tissue for 1 hr	7.3±0.24	8.0±0.18	<0.05
Consumption of P$_i$, microatoms of P$_i$ per 100 mg of tissue for 1 hr	17.7±1.2	22±0.9	<0.01
P/O coefficient	2.4±0.12	2.8±0.13	<0.05
Succinate dehydrogenase activity, ΔE per 1 mg of protein for 1 hr	13.5±1.1	15.4±1.1	>0.05
Citochrome oxidase activity, ΔE per 1 mg of protein for 1 hr	14.7±0.9	15.8±1.3	>0.05
Content of			
RNA, mg%	19.8±0.3	18±0.3	<0.01
DNA, mg% (three months of action)	13±0.68	10±0.45	<0.01

alternating magnetic field, the content of the basic energy substrates of the nerve tissue—glycogen and glucose—diminishes under the influence of the intermittent magnetic field. But the reasons responsible for this drop are evidently different. Most likely in the latter case, the reduction of the amount of glycogen and glucose in the brain tissue is accompanied by an activation of the oxidizing conversions of the carbohydrates, confirmation for which is to be found in the increased consumption of oxygen accompanied by the retention within the limits of control magnitudes of key enzyme activities of glycolysis and the pentose phosphate cycle (hexokinase, lactate dehydrogenase and glucose-6-phosphate dehydrogenase).

Together with a certain activation of the intensity of oxidizing processes under the action of the intermittent alternating magnetic field, there is a significant increase in the capacity of the brain tissue to esterify the inorganic phosphate. The P/O coefficient in the brain of the irradiated rats grows reliably, which may attest to a reduction in the relative share of free oxidation. The ATP level and its dephosphorylated derivatives (ADP and AMP) under these conditions reliably do not change, but the content of creatine phosphate is reduced. It may be assumed that the alternating magnetic field of the investigated intensity, being a powerful stimulus of nerve tissue, results in a long and excessive excitation of the central nervous system, which is accompanied in addition to other processes by an intensified breakdown of creatine phosphate. Activation of the oxidizing breakdown of carbohydrates as well as a reduction in the share of free oxidation may be considered under such conditions obviously as a compensating reaction aimed at making up the level of macroergs, particularly ATP. As for the lowered level of creatine phosphate existing under these conditions, its reduction is accompanied obviously by a certain suppression of creatine kinase or is caused by it, and it is evidently most probable that the creatine phosphate, being the provider of the macroergic phosphate groups, is also used for the maintenance of the ATP level under a functional load.

Positive changes in the remaining indicators, with the exception of the reduction of the DNA content under the repeated action and of the RNA and DNA in the third month were not observed. The absence of changes in the activity of depolymerase of nucleic acids makes it possible to suppose that the reduction of the RNA and DNA content in the brain tissue is most probably connected with slowing down of their synthesis.

Thus the obtained data testify to the fact that the difference in the effect of alternating magnetic fields of different parameters is evidently due to the intensity and regime of modulation, character of the influence of the field on the intensity of oxidizing conversions of carbohydrates and accompanying processes of accumulation of energy in macroergic relations and processes of synthesis of nucleic acids in brain tissue.

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[353-7697]

7697
CSO: 1840

UDC 356.33:614.876+612.014.426]:006.88

EFFECTS OF HF AND UHF RADIATION ON THE ORGANISM AND THE PRINCIPLES OF STANDARDIZATION

Moscow VOYENNO-MEDITSINSKIY ZHURNAL in Russian No 4, 1980 pp 65-68

YERMOLAYEV, Ye.A., SUBBOTA, A.G., CHUKHLOVIN, B.A.

[Abstract] The thermal and biological effects of high-and ultrahigh-frequency fields on the human organism have been studied since 1926. A direct correlation was found between a number of infectious diseases and solar activity. The thermal and nonthermal effects of high-and ultrahigh-frequency fields were established. The thermal effect of these fields was used extensively in physical therapy for deep heating of the organism and tissues. The nonthermal effect of electromagnetic fields was debatable for a long time. The effective levels of electromagnetic fields, found experimentally and by calculation, were identical or very close to each other at different frequencies. Very high levels of these fields cause morphological changes in the tissues and significantly raise the body temperature, which causes animals to die. References: 12 Russian, 1 Western.
[400-6521]

UDC 614.8.026:63

CAUSES OF OFF-DUTY ACCIDENTS AMONG AGRICULTURAL WORKERS

Moscow SOVETSKOYE ZDRAVOOKHRANENIYE in Russian No 2, 1980 pp 41-46 manuscript received 5 Feb 79

CHERNOBAY, V.A., Scientific Research Institute of Traumatology and Orthopedics and Health, Belorussian SSR Ministry of Public Health

[Abstract] Statistical analysis of the sites and causes of non-occupational injuries among the population of the Osipovichskiy and Pukhovichskiy rayons of Belorussian (669 cases, with and without loss of ability to work among workers of 45 kolkhozes and sovkhozes) revealed that on the average 29.3 out of every 1000 workers suffer such injuries, and most of them are of the most ablebodied age (30 to 50 years). The accidents occurred mostly at home or in the farmyard, and chiefly during the summer season (33.2 percent of cases) as well as on weekends, and in 14.05 percent of cases they were associated with intoxication due to the imbibing of alcoholic beverages. They include wounds, fractures, abrasions, burns, lacerations, and so on. Most of the injuries were sustained while caring for livestock and poultry, repairing farm

buildings, and logging. Analysis reveals that accident prevention requires a differentiated approach allowing for the various principal causes of accidents. Knowledge of proper work techniques should be disseminated, improved sanitary measures should be taken, and drunkenness and moonshine stills should be combatted. References 5: all Russian.
[323-1386]

EFFECT OF HETEROGENEOUS MAGNETIC FIELD ON HUMAN ERYTHROCYTES

Moscow BIOFIZIKA in Russian No 2, 1980 pp 353-355 manuscript received 19 Jul 79

KONDORSKIY, Ye. I., NORINA, S.B., and SHALYGIN, A.N., Physics Department of Moscow State University imeni M.V. Lomonosov

[Abstract] Experiments were conducted on a suspension of erythrocytes put close to the surface or end of thin ferromagnetic wire magnetized with a laboratory electromagnet. Construction of trays is described. Erythrocytes were taken from heparinized blood of healthy donors. On the basis of the findings the magnetic method of separating erythrocytes is proposed. Figures 2; references 4: 1 Russian, 3 Western.
[309-10,657]

UDC 615.84:591.1

FREE-RADICAL ACTIVITY OF MITOCHONDRIA FOLLOWING EXPOSURE TO ELECTROSTATIC FIELD

Yerevan BIOLOGICHESKIY ZHURNAL ARMENII in Russian Vol 32, No 11, 1979 pp 1112-1116 manuscript received 13 Jun 79

ARTSRUNI, G.G. and MKRTCHYAN, S.L., Yerevan, State Medical Institute, Laboratory of Biophysics and Molecular Biology, Central Scientific Research Laboratory, Chair of Biochemistry

[Abstract] One of the significant indices that characterize the functional state of mitochondria is the concentration in them of the stable free radicals with a g-factor similar to a g-factor of the unpaired electron, which can be revealed by the EPR method. It has been demonstrated by a number of researchers that the level of the free radical activity in mitochondria depends on such important processes as the transfer of electrons, alteration of the redox state of the respiratory carrier chain, on the activity of its individual sectors, and on the ATP-synthesizing system. To study the intensity of the EPR signals in mitochondria, following their exposure to the electrostatic field (ESF), and the mechanism of disturbances of the energy metabolism, experiments were carried out on male albino rats, weighing 150-180 g, by subjecting them to the ESF action of 2000 v/cm intensity, for 1 hour, for 24 hours, and for a week 6 hours a day. The data obtained showed that the action of the ESF at all exposures leads to a decrease in the concentration of free radicals in mitochondria and that the highest change in the EPR signal is experienced after a 24-hour exposure to ESF, which agrees well with the results of authors' previous investigations and confirms the existence of a close connection between duration of

of the exposure and the functional state of mitochondria. After discussing the role of processes of the ATP-synthesizing reaction in light of the modern view of the nature of the stable free radicals in mitochondria with a g-factor 2.004 and their two types, the authors came to a conclusion that the observed EPR signal is probably related to the electrocarrying (and not the ATP-synthesizing) system, in which the greatest changes apparently occur as a reuslt of the exposure to ESF. Table 1, figure 1, references 10: 9 Russian, 1 Western.
[314-1015]

UDC 615.84

DYNAMICS OF PROTEOLYTIC CHANGES IN RAT LIVER FOLLOWING EXPOSURE TO ELECTROSTATIC FIELD

Yerevan BIOLOGICHESKIY ZHURNAL ARMENII in Russian Vol 32, No 11, 1979 pp 1117-1123
manuscript received 24 Jan 79

ARTSRUNI, G.G., OVSEPYAN, R.S. and PEPANYAN, G.S., Yerevan Medical Institute, Central Scientific Research Laboratory, Laboratory of Biophysics and Molecular Biology

[Abstract] Proteolysis in the liver of rats was investigated at various periods of time following exposure to an electrostatic field (ESF) of 2000 v/cm intensity. Three groups of 50 albino males, each weighing 150-170 g, were exposed to ESF, for 1 hour in the 1st group, for 24 hours in the 2nd, and for 6 days, 6 hours a day, in the 3rd group. The intensity of proteolysis was estimated from the increase in the amount of free amino acid nitrogen in the incubated liver homogenates. Determination was made according to the Jemm and Corking method. The results obtained showed that exposure to ESF leads to a pronounced depression of proteolytic reactions. Directly after 1 hour exposure to ESF the amount of amino nitrogen decreases significantly both in vivo and in vitro. Subsequent testings (after 1, 4, 7 and 12 days) show no essential differences in proteolysis between the control and experimental animals. The sharpest changes in proteolysis occur after 24-hour and 6-day exposures. One day after 24-hour exposure not only the starting amount of amino nitrogen is less but the rate of protein decomposition in vitro also decreases. After 4 days, the proteolysis in vivo is almost restored to normal, but in vitro its sharp inhibition is still observed. After 7 days a repeated decrease occurs both in intensity and in the rate of protein decomposition, and after 14 days proteolysis in the liver of experimental rats approaches its control level. In the 6-day exposure the shifts are analogous with the difference that on the 7th day the inhibition is observed only in the incubated samples, whereas in the starting sample the amount of amino nitrogen doesn't differ from that in the control. Discrepancy in the results of proteolysis in vivo and vitro is due, in the opinion of authors, to the operation of compensating mechanisms of the intact organism. The dynamics of proteolytic changes following the exposure to ESF agrees well with the author's previous investigations. At the present stage, it is not yet possible to speak of concrete mechanisms of the ESF effect on the proteolytic processes. Tables 3, references 14: 7 Russian, 7 Western.
[314-1015]

UDC 616.36-002.14-022.6-085.847.8

TREATMENT OF VIRAL HEPATITIS PATIENTS WITH LOCALIZED MAGNETIC FIELD

Alma-Ata ZDRAVOOKHRANENIYE KAZAKHSTANA in Russian No 5, May 80 pp 52-55

SYZDYKOV, M.S., Chair of Infectious Diseases, Karagandinsk Medical Institute and Municipal Hospital Clinic of Infectious Diseases

[Abstract] The clinical course of viral hepatitis was studied on two groups of patients: one received the standard therapy consisting of controlled diet, glucose and vitamins, the other group was in addition exposed to magnetic field therapy. Both groups received glucocorticoids when indicated. The magnetic therapy consisted of daily 15 or 25 min exposure to a magnetic field of 450-550 oersted. The patients subjected to magnetic therapy felt better and showed improved appetite after only a few days. The toxic manifestations of the hepatitis disappeared in 68 percent of this group of patients in comparison to 48 percent of the controls. Many of the clinical and laboratory indices, including increased nonspecific immunoreactivity of the organism showed improvement in the group receiving magnetic therapy. The method is simple, economical and non-invasive. No references.
[14-7813]

UDC 616-006.04-08:y15.849

APPLICATION OF MICROWAVE HYPERTHERMIA IN THE TREATMENT OF MALIGNANT TUMORS

Leningrad VOPROSY ONKOLOGII in Russian No 3, 1980 pp 59-63 manuscript received 21 Apr 79

LOPATIN, V.F., Obninsk, Scientific Research Institute of Medical Radiology, USSR Academy of Medical Sciences

[Abstract] The usefulness of microwave fields as an agent for generating differentiated and local hyperthermia in the tumor and in the surrounding tissues was investigated on 148 rats of the Wag line with a P-1 tumor grafted in the femoral region. The tumors were heated by means of the microwave field of an UVCh-30 apparatus, at temperatures of up to 45°C on measuring the temperature difference in the tumor and in the surrounding tissues as well as the general (rectal) temperature or the organism. It was found that the temperatures 42-43°C represent a thermal threshold above which the heat death of tumor cells sharply increases. The temperatures 41-41.5°C, which in themselves do not produce a tumorolytic effect, prevent lethal damage to tumor cells upon subsequent heating at higher temperatures (44.5-45°C). Finally, the resumption of tumor growth in peripheral areas following partial destruction of tumors by hyperthermia is an indirect proof that the maximum damage to and death of tumor cells occur in the central zones of the neoplasm, in which circulation is minimal and temperature--as shown by interstitial thermometry--maximal. This finding is in agreement with the hypothesis of the more destructive effect of radiowaves in tissues with insufficient circulation, i.e., in particular, in the hypoxic and anoxic fractions of the tumor cells. The fact that local microwave hyperthermia causes primarily

the overheating and death of the hypoxic and anoxic fractions of tumor cells, which are the most radioresistant, is particularly significant from the standpoint of combining microwave hyperthermia with ionizing radiation treatment. Figure 1; references 5: 3 Russian, 2 Western.
[326-1386]

UDC 616.7-001.5-089-085.857.8

USING A PERMANENT MAGNETIC FIELD IN TREATMENT OF INJURIES TO THE LOCOMOTOR SYSTEM IN EXPERIMENT AND UNDER CLINICAL CONDITIONS

Minsk ZDRAVOOKHRANENIYE BELORUSSII in Russian No 3, 1980 pp 46-47 manuscript received 9 Feb 79

ZHELEZNYAK, V.A., NIKOL'SKIY, M.A. and FEDOROVA, R.I., Department of Traumatology and Orthopedics of the Vitebsk Medical Institute

[Abstract] The effect of a permanent magnetic field on healing of wounds and fractures was studied. It was established that flexible magnets, synthetic rubber impregnated with barium ferrite, have an antiinflammatory and hypocoagulative effect. No inflammatory infiltration was detected in histological study of the connective-tissue and bone regenerates in 45 rabbits exposed to the constant effects of a 50-oersted magnetic field. Accelerated differentiation of the connective tissue was noted. Regenerative processes in the bone tissue develop more actively when exposed to magnets. The initial features of callus formation in the form of fine periosteal proliferations appear within 7 days and the same effect is achieved by the 14th day as that reached in control animals by the 30th day. No negative effects of the magnets were determined. Magnetotherapy was begun in most patients on the second day after operation or admission to the hospital if conservative treatment was prescribed. Magnetotherapy was prescribed from the 4th to the 6th days after the operation for some patients after the appearance of early symptoms of infectious complication of postoperative wounds. Since late 1977 magnetotherapy has been prescribed immediately after operation or admission of the patient to the hospital. The experimental and clinical data indicate that a permanent magnetic field of 50 oersteds under experimental conditions and a flexible magnetic field of 350-500 oersteds under clinical conditions applied locally for 30-40 minutes daily for 10-20 days has a positive effect on treatment of closed and open injuries to the locomotor system. Having an antiinflammatory and spasmolytic effect, this action reduces post-traumatic edema, normalizes the anticoagulating system and accelerates regenerative processes of the bone tissue.
[322-6521]

UDC 617.7-002:616.523-085:615.847.8

VARIABLE MAGNETIC FIELD USED IN THE TREATMENT OF HERPETIC DISEASE OF THE EYES

Odessa OFTAL'MOLOGICHESKIY ZHURNAL in Russian No 5, 1980 pp 278-281

VAYNSHTEYN, Prof Ye. S., ZOBINA, L.V., candidate of medical sciences, and LARINA, L.A., junior scientific worker, Moscow Scientific Research Institute of Eye Diseases imeni Gel'mgol'ts

[Abstract] In view of reports of clinical and experimental results of using magnetic fields in surgery, gynecology, dermatology, orthopedics, etc., and variable magnetic fields, testing of which showed them to be harmless to the eye, the latter therapy was administered by the author to 85 patients with herpetic eye disease (epithelial and stromal keratitis, keratouveitis, postherpetic trophic keratitis). Most patients had received in-and out-patient drug therapy without adequate response previously. The beneficial effects of variable magnetic fields, using the Polyus-1 low-frequency magnetic therapy machine, are tabulated: attenuation or disappearance of pain, lacrimation, photophobia, palpebral edema, mixed injection, epitheliopathy, stromal edema, descemetitis, exudate in anterior chamber, with epithelization of superficial and deep ulcerations. Visual acuity improved in most cases. The advantages of magnetic field therapy are discussed, and they include the feasibility of starting therapy for ophthalmoherpes from the very first day, which cannot be done with other methods, such as phonophoresis and electrophoresis. Tables 5. References 12 Russian.
[89-10,657]

UDC 615.849.112.03:616-002.5+616-002.5-085.849.112

MECHANISM OF ANTIINFLAMMATION EFFECT OF MICROWAVES

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 2, 1980 submitted 21 Jun 79 signed to press 5 Mar 80 pp 18-21

GRIGOR'YEVA, V.D., Central Institute of Health Resort Study and Physiotherapy, Moscow

[Abstract] A discussion of existing information concerning the antiinflammation effect of microwaves emphasizes the uncertainty and difference of opinions concerning aspects of this phenomenon. The importance of weak thermal doses was emphasized. Low doses inhibit processes determining the intensity of inflammation and stimulate activation of adaptive systems and restorative processes while large doses may worsen the inflammation process. There is need for more study on the effect on lysosomic and enzymic systems and on cellular and humoral factors. References: 28.
[398-2791]

THE MAGNETIC SUSCEPTIBILITY OF MICROORGANISMS

Prague ZHURNAL GIGIYENY EPIDEMIOLOGII, MIKROBIOLOGII I IMMUNOLOGII in Russian No 23(3), 1979 pp 230-233 manuscript received 26 Jul 77

CHERVINETS, V.M., NOVITSKIY, Yu. and PAVLOVICH, S.A., Kalinin Medical Institute and the Institute of Plant Physiology of the USSR Academy of Sciences, Moscow

[Abstract] The method of measuring the magnetic susceptibility was used to characterize the bacteria grown under natural conditions of the geomagnetic field and after prolonged passage through a weak fluctuating magnetic field, using 13 species and varieties of bacteria as specimens. The materials were processed statistically by the modified Moncevicut-Eringen method and the results of calculating the magnetic susceptibility were tabularized. The total magnetic susceptibility of the different cultures fluctuated over a wide range, but this value remained constant for each species and strain of bacteria in all subsequent experiments. The prolonged effects of an artificial magnetic field of 0.1 oersted, changing every 3 minutes, alters the magnetic susceptibility of some bacteria, indicating a low threshold of their magnetic susceptibility and possible mutability of the microbes due to natural fluctuations of the geomagnetic field. Figures 1; references 9 : 6 Russian, 3 Western.
[226]

THE EFFECT OF AN EXPERIMENTAL MAGNETIC STORM ON PRODUCTION OF PHAGE λ

Prague ZHURNAL GIGIYENY EPIDEMIOLOGII, MIKROBIOLOGII I IMMUNOLOGII in Russian No 23 (3), 1979 pp 234-237 manuscript received 9 Dec 77

CHERVINETS, V.M., Kalinin Medical Institute, USSR

[Abstract] The biological effect of the vertical component of a fluctuating magnetic field, varied by ± 0.1 oersted with respect to the geomagnetic field every 3 minutes over 24 hours, was studied. Standard cultures of lysogenic bacteria E. coli K-12 and the streptomycin-resistant indicator strain E. coli C-85 were used as the test specimens. Both strains of E. coli react to slight changes of geomagnetic field intensity. The vertical component inhibits production of the free phage in the lysogenic system and this effect increases upon repeated passage through the variable geomagnetic field. Figures 1; references 14: 10 Russian, 4 Western.
[226]

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